

TAXONOMY AND BIOLOGY OF THE GENUS
LEBETUS (TELEOSTEI-GOBIOIDEA)

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TAXONOMY AND BIOLOGY OF THE GENUS *LEBETUS* (TELEOSTEI-GOBIOIDEA)

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ABSTRACT

The marine gobioid genus *Lebetus* Winther 1877 is redefined and previous division into two species—*orca* Collett 1874 and *scorpioides* Collett 1874—shown to be based on sexual dimorphism in one species, by page priority *L. orca*. A redescription of the species is provided including details of sensory papillae and osteology. *L. orca* is eastern Atlantic boreal in distribution, occurring as a small predator on coarser grounds down to 375 m. Specialization of the male genitalia and sexual dimorphism are described and the breeding season provisionally regarded as from March to August. The skeleton of *Lebetus* is typically gobioid, and evidence is presented for a closer relationship to the genus *Buenia* Iljin as represented by *B. jeffreysii* (Günther) than to the Mediterranean *Odondebuena* De Buen and *Cabotichthys* Whitley with which *Lebetus* had been previously grouped.

INTRODUCTION

THE genus *Lebetus* was founded by Winther (1877) to contain two species of gobies dredged by G. O. Sars on the coast of Norway and described by Collett (1874) as *Gobius orca* and *G. scorpioides*. These species have subsequently been regarded as among the rarest of European Atlantic fishes and, until recent years, the numbers of demersal individuals known to science have been relatively few. In the last fifteen years, protracted dredging surveys off the Isle of Man (Jones, 1951; Hartnoll, 1961) have yielded many examples. Their small size and occurrence on rough grounds makes collecting difficult; in Manx waters, most specimens have been obtained by means of a scallop dredge lined with shrimp netting. Relative infrequency of capture is probably due to inadequacies of the fishing gear rather than to actual rarity, and occasional hauls providing up to five individuals suggest the presence of appreciable numbers in the area. Other long term faunistic investigations within the range of the genus have produced more or less sizeable collections of both demersal (Grieg, 1913; Le Danois, 1913) and planktonic stages (Petersen, 1919; Johansen, 1925; Russell, 1926-1940).

My interest in these fishes was aroused firstly by the difficulty experienced in separating the two species. After endeavouring to use the diagnoses of several authors, it was found possible to achieve this only on the basis of coloration. Then, while examining the testes of various gobies, it was noticed that no female *L. orca* were present in a collection of twenty two dissected individuals, and only immature males among twenty eight *L. scorpioides*. The possibility that the two so-called species were in fact based on sexual dimorphism in a single species indicated the need for taxonomic revision. Although such a view was put forward by Smitt (1900), this was not accompanied by any evidence and appears to have been overlooked by later authors. Dissection of the extensive material from the Irish Sea presented opportunities for settling the position of *Lebetus* among the gobioid families by osteological

study, and also for investigating various aspects of diet and reproduction. A preliminary account of some of this work has already been published (Miller, 1961b).

MATERIAL AND METHODS

The following specimens have been available for examination :

Isle of Man : 3 ♂♂, standard lengths 15.75–30.0 mm., including BMNH 1961.10.17.1, 3, 5, and one in PEM, and 27 ♀♀, 14.5–29.0 mm., inc. BMNH 1961.10.17.2, 4, and one in PEM.

Other British localities : 3 ♂♂, 12.0–30.0 mm., BMNH 88.3.22.9–10 part and BMNH 1903.4.14.4–7 part, and 2 ♀♀, 10.5 and 17.0 mm., BMNH 1903.4.14.4–7 part.

Scandinavia : 13 ♂♂, 13.5–26.0 mm., ZMO J3999 (type of *Gobius orca*), J4000, J4001, J4023 ; ZMB 771, 1887, 1893, 1966, 4174, 4175, 5294 ; ZMC 89, 91 ; and 4 ♀♀, 21.75–29.0 mm., ZMO J4020, J4021 (types of *G. scorpioides*) ; ZMB 536, 2009.

Abbreviations for museums are as follows :

BMNH	British Museum (Natural History).
PEM	Port Erin Marine Biological Station Museum.
ZMB	Zoologisk Museum, Universitetet i Bergen.
ZMC	Universitetets Zoologisk Museum, Copenhagen.
ZMO	Zoologisk Museum, Universitetet i Oslo.

The specimens were viewed by means of low power binocular and dissecting microscopes. With suitable illumination the sensory papillae were readily seen without staining after careful removal of mucus from the head and body surfaces. The skeleton was investigated by dissection of alizarin stained whole-mount preparations.

THE GENUS *LEBETUS* WINTHER 1877

Lebetus Winther, 1877 : 49 (orthotype *Gobius scorpioides* Collett 1874) ; Smitt, 1900 : 554 ; Jordan, 1919 : 392 ; 1923 : 225 ; Duncker, 1928 : 140 ; Iljin, 1930 : 55 ; De Buen, 1930a : 123 ; 1930b : 5, 21 ; Koumans, 1931 : 43, 46 ; Whitley, 1931 : 155 ; De Buen, 1931 : 50, 54, 61 ; 1940 : 3 ; 1951 : 56, 57 ; Norman, MS : 413.

Lebistes Jordan, 1920 : 487 ; 1923 : 226 (*non* Filippi, 1862 : 69).

Butigobius Whitley, 1930 : 123.

Body moderately elongate, subcylindrical, with 25–29 ctenoid scales in lateral series. Head, nape, and back naked to origin of second dorsal fin, lacking skin folds or barbels. Postorbital length not more than half length of head. Anterior nostril a short tube. Opercle without scales. Preopercle and lower jaw unarmed. Branchiostegous membranes attached to sides of isthmus, but not fused across isthmus. Jaws oblique, subequal, maxillae ensheathed and not elongate. Teeth of both jaws in several rows, simple, erect. Tongue truncate to very weakly emarginate, free from floor of mouth anteriorly. Pelvic fins united along entire length, without anterior membrane (frenum) and with fourth branched ray somewhat produced. Pectoral girdle lacking flaps on anterior edge ; uppermost rays of pectoral fin not free from membrane. Dorsal fins separate, first dorsal with 6 rays, not pungent. Caudal fin rounded, not much longer than head.

Cephalic canals absent. Sensory papillae prominent but reduced in number. Two pairs of interorbital papillae (*p*). Cheek with only suborbital row *a*, a short longi-

tudinal row *c*, and an intermediate papilla; row *d* without posterior longitudinal section. Anterior dorsal (occipital) series (excluding *h*) in two groups of a few papillae. Opercular transverse row *ot* in two sections. Preoperculo-mandibular series in several parts.

In compiling his work on the genera of fishes, Jordan (1919, 1920, 1923) includes, together with *Lebetus* Winther 1877, the genus *Lebistes* Smitt 1899. Since Jordan gives "*L. scorpioides* Smitt" as the orthotype of this genus, the latter, as noted by Koumans (1931), is clearly an erroneous reference to *Lebetus* for which Smitt (actually 1900, not 1899) indicated *Gobius scorpioides* Collett as the type. The generic name *Lebistes* is preoccupied by *Lebistes* Filippi 1862 among the cyprinodont teleosts and, to replace this name within Jordan's list of gobiid genera, Whitley (1930) proposed *Butigobius* without consulting Smitt's paper. In a later account, Whitley (1931) unravels this confused story.

THE SPECIES OF THE GENUS

The present section embodies a review of the various characters proposed by earlier authors as being of value in the diagnosis of *L. orca* and *L. scorpioides*.

Coloration. The two species are reputed to differ in both body and fin coloration. The body of *Gobius orca* was described by Collett (1874, 1875a) as uniformly greyish except for darker areas between the second dorsal and anal fins, and at the root of the caudal fin, while that of *G. scorpioides* was said to possess four or five dark brown vertical bands across the sides. After examination of a living *scorpioides*, Winther (1877) remarked on the colourless caudal peduncle, and both Holt & Byrne (1903) and Le Danois (1913) emphasized the importance of this pale band, sharply demarcated anteriorly, as a means for the identification of *L. scorpioides*. In the original description, Collett (1874) mentioned that the second dorsal fin of *G. orca* had an indistinct white band in its outer half whereas the same fin in *G. scorpioides* showed only ill-defined banding. Alternate dark brown and snow white bands were found across the second dorsal fin of a later specimen of *G. orca* (Collett, 1885). Holt & Byrne (1903) regarded a superior black band to this fin as characteristic of *G. orca* and in their text referred to a row of white spots immediately below the dark periphery. These authors described and illustrated the second dorsal fin in *G. scorpioides* as banded with red, the markings in some cases being flanked by dark edging.

With the collection of *Lebetus* amassed for this work, it has been possible to segregate the individuals into two groups on the basis of differences in the coloration of the second dorsal fin. In the first of these, termed the *orca* group, the second dorsal fin has a thick black superior edge, below which occur white areas and wide oblique bands, yellow or ochre in life but grey in preserved material. Within the *scorpioides* group, the black edge to the second dorsal fin is present but much thinner and less intense than in the *orca* examples. The rest of the fin bears merely four narrow double lines of melanophores, enclosing in the living fish thin red or ferruginous striae, and separated by hyaline fin membrane. Among living *scorpioides*, madder brown lateral marks are pronounced on the body which, in *orca* fishes, is more uniform grey or yellowish grey although comparable markings may be quite prominent. A pale band on the caudal peduncle is more clearly defined in the *scorpioides* group, especially

when preserved, but living *orca* show this feature to a noticeable degree (cf. Pl. I and Text-fig. 3) and it is shown in Collett's illustrations of *Gobius orca* (1875a, 1885).

TABLE I.—*Relation of Coloration Groups to Sex and Maturity Stage*

Group	No. of males		No. of females all stages
	Mature and developing	Immature	
	(a) Dissected		
<i>orca</i>	21	1	
<i>scorpioides</i>		6	22
	(b) Not dissected		
<i>orca</i>	16		
<i>scorpioides</i>		5	11

The relation of these two colour patterns to sex and to gonad maturation is indicated in Table Ia, based on fifty Manx specimens whose sex and sexual development were confirmed by dissection. The sex and approximate maturity stage in a further thirty two British and Scandinavian examples have been determined by inspection of the genital papilla (Text-fig. 17), and these results are given in Table Ib. It is apparent that mature or developing male *scorpioides* do not occur, and that female *orca* are unknown at any stage of maturation. This distribution strongly implies that the *orca* coloration is the male livery of a species whose females and immature males bear the markings of *scorpioides*. Incipient development of the *orca* pattern in the second dorsal fin can, in fact, be noted among some of the immature males in the *scorpioides* group, which usually exhibit a pronounced black spot on the distal part of the first two interradian membranes of the second dorsal fin (see Le Danois, 1910, fig. 4). The above hypothesis is further supported by the range in standard length found in the three categories shown in Table II. The examples of *orca* are from 18.0–30.0 mm.

TABLE II.—*Standard Length Frequency in Coloration Groups, Expressed in 2 mm. Length Groups*

Coloration group	Standard length										
	10	12	14	16	18	20	22	24	26	28	30
<i>orca</i>					1	1	10	16	7	1	2
♂ <i>scorpioides</i>		2	3	3		2	1				
♀ <i>scorpioides</i>	1		1	2	1	2	5	9	5	7	

in length while male *scorpioides* do not exceed 23.0 mm. Tåning (1940) has reported juvenile *Lebetus orca* of 5–15 mm., but relied for the identification on meristic characters whose validity is doubtful. Female *scorpioides* attain about the same maximum length as that for *orca*.

The first dorsal fin in the *orca* individuals is a uniform yellowish grey edged with white, but in *scorpioides* is usually banded with a dark spot on the interradian membrane between the fifth and sixth rays. Confluence of these bands frequently occurs, and the spot may not be very distinct. This *scorpioides* group pattern is stated by

Holt & Byrne (1903) to be found only in the breeding male of "*Gobius scorpioides*". Fage (1918) regarded the presence of a black spot on the first dorsal fin of a 12.5 mm. example from the Dana collections as a sign of precocious development of supposed male coloration. However, in the material under consideration, the spot is well represented in adult females and among male *Lebetus* occurs only in the immature where it is not uncommonly absent. The single female *G. orca* mentioned in the literature was taken by Patience (1906) in the Firth of Clyde. This specimen has not been traced. The diagnosis of *G. orca* given by Patience was not derived from his own examples but seems to be a translation from Collett (1896) and could apply to individuals of either the *orca* or *scorpioides* group.

TABLE III.—*Meristic Characters Cited for Lebetus orca and L. scorpioides*

No. of fin rays					No. of Verte- brae	No. of Scales in l.l.	Authority
First dorsal	Second dorsal	Anal	Pectoral	Caudal			
<i>L. orca</i> ¹							
VI	11	10	18	3/13/3		28	Collett, 1874
VI	11	9	17	3/13/3		28	Collett, 1875a
VII	10-11	9	17	3/12-13/3		24	Collett, 1885
VII	1/9-10	1/8	17	12-13		25	Lilljeborg, 1884
VI-VII	1/9-10	1/8	17	x/13/x		c. 24	Smitt, 1892
VII	10-11	9	17	3/12-13/3			Collett, 1896
VI-VII	9-11	9-10				25-28	Holt & Byrne, 1903
VI-VII	1/9-10	18 (<i>sic</i>)	17-18	12-13		25-26	Duncker, 1928
VI-VII	1/9-10	1/8-9				24-28	De Buen, 1930a, b
VI-VII	10-12	8-10	18-20	7-8/11/6-7	28-29		Tåning, 1940
<i>L. scorpioides</i> ^{2, 3}							
VI	9	8	20 (18)	6/12/6		28	Collett, 1874
VI	9	8	18-20	6/12/6		28	Collett, 1875a
VI	9	8	c. 18	12		30	Winther, 1877
VI	1/8	1/7	18-20	12		28-30	Lilljeborg, 1884
VI	1/8	1/7	18-20	x/12/x		c. 28-30	Smitt, 1892
VI	9	8				28-30	Holt & Byrne, 1903
VI	9	7-8	18-20	x/12/x		28	Le Danois, 1910
VI	1/9	1/6				28	Le Danois, 1913
VI	1/8-9	1/6-9			27-28	28	Fage, 1918
VI	8-9	6-8			25-26		Petersen, 1919
V-VI	1/7-8	1/6-7	18-20	12	25-26	26-30	Duncker, 1928
VI	1/8-9	1/6-7	18-20	x/12/x		28-30	De Buen, 1930a, b, 1932

¹ Scales in l.l. c. 26-c. 28 (Grieg, 1913). ² Scales in l.l. 26, D₁ V (Collett, 1902). ³ Scales in l.l. 28 (Grieg, 1913).

Meristic characters. Radial formulae, vertebral and scale counts provided by various authors for the two species are shown in Table III. Although Collett originally ascribed 6 elements to the first dorsal fin of both species, he later changed this to

7 for *G. orca*. Lilljeborg (1884) and Smitt (1892) employed this supposed disparity in keys to Scandinavian gobies. *L. orca* is also regarded as having rather more articulated rays in the second dorsal and anal fins than *L. scorpioides*, and slight differences are indicated in pectoral and caudal fin ray counts. The number of scales along the lateral midline is reputed to be greater in *L. scorpioides* than in *L. orca*.

For the *orca* and *scorpioides* groups of the present material the meristic values in Table IV have been obtained. Methods of counting are described in the systematic section below. To minimise the effect of regional variation, results for British and Scandinavian collections have been kept separate. Mean values are given for the more numerous British material.

TABLE IV.—*Meristic Characters of Coloration Groups: Number of Observations (Highest in Bold Type) Against Value. M = Mean Value for British Material*

Coloration group	Origin of specimens													
	British Isles							Scandinavia						
	First dorsal fin rays													
	5	6	7					5	6	7				
<i>orca</i>		26							7	1				
<i>scorpioides</i>		34							6					
	Second dorsal fin articulated rays													
	6	7	8	9	10	11	M	8	9	10	11			
<i>orca</i>			1	18	7		9.23		5	3	1			
<i>scorpioides</i>	1	2	4	21	6		8.85	2	4	1				
	Anal fin articulated rays													
	5	6	7	8	9	M		5	6	7	8	9		
<i>orca</i>		1	19	6		7.19				5	4			
<i>scorpioides</i>	3	2	22	7		6.97		1		4	1			
	Pectoral fin rays													
	15	16	17	18	19	20	21	M	17	18	19	20	21	
<i>orca</i>			2	15	20	15		18.92		7	4	2		
<i>scorpioides</i>	1	4	7	9	30	10	1	18.56			4	2		
	Caudal fin branched rays													
	8	9	10	11	M			8	9	10	11			
<i>orca</i>			24	1		9.04			5					
<i>scorpioides</i>	2	31	1			8.97		2						
	Scales in lateral series													
	25	26	27	28	29	M		25	26	27	28	29		
<i>orca</i>	2	18	10	6	2	26.68		1	3	2	1			
<i>scorpioides</i>	1	17	17	6	1	26.74		1	1	2				
	Vertebrae including urostyle (Manx specimens only)													
						26	27	28	29	M				
<i>orca</i>							2	13	1	27.94				
<i>scorpioides</i>						1	3	17		27.76				

Except for pectoral ray and scale counts in the Scandinavian fishes, where the number of observations is small, the most common value for each meristic character is the same in the two coloration groups and mean values are only slightly different. The wider range and somewhat lower means for fin ray counts in *scorpioides* are due

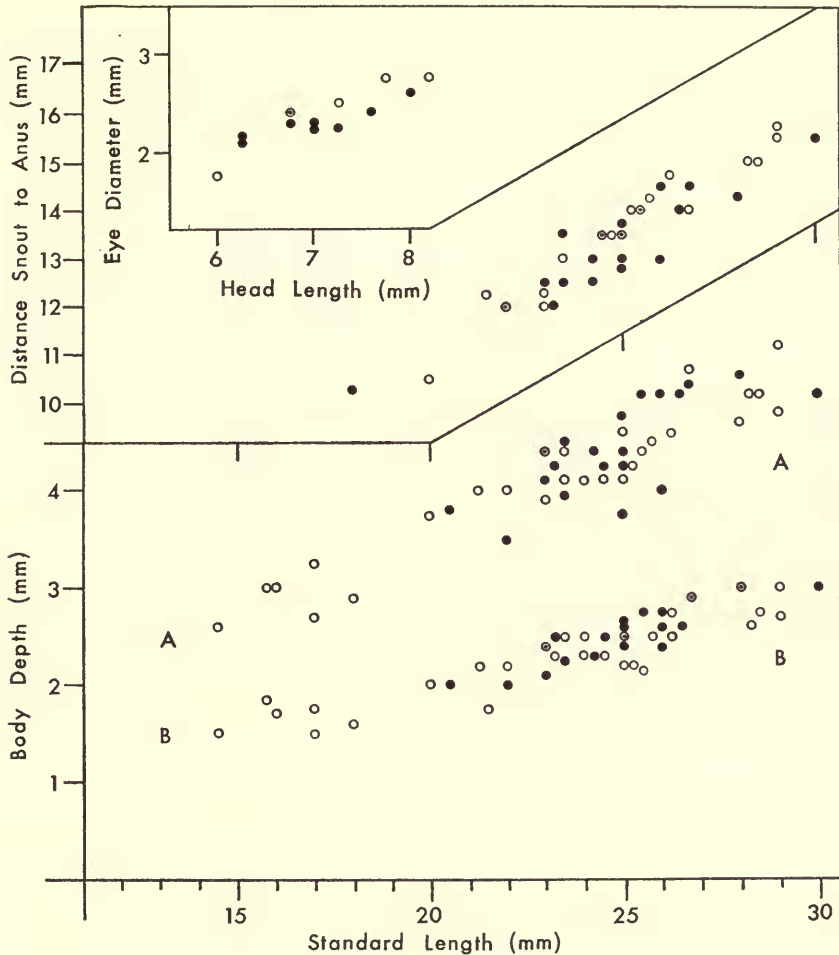


FIG. 1. Relation between standard length or head length and certain body measurements in the two coloration groups. A, body depth at origin of pelvic fin; B, depth of caudal peduncle before origin of caudal fin; ●, *orca*; ○, *scorpioides*; ⊙, coincident points.

to the occurrence in this group of all the youngest and smallest individuals, among which such variation, as may be expected, is more pronounced (Barlow, 1961a). The specimen of *G. orca* (ZMO J4023) which prompted Collett (1885) to believe in a difference in first dorsal count between the two species has been examined and is the only individual among seventy-four examples of *Lebetus* to have seven first dorsal rays. Another fish, identified by Collett (1902) as *G. scorpioides*, was des-

cribed by this author as having only five first dorsal rays. This specimen (ZMB 536) has also been studied, and was found to possess an abnormal first dorsal fin (not included in Table IV) with only four rays, the first three of which are separated by an unusually large interspace from the last ray.

Body proportions. From their first description, *L. orca* has been held to be consistently slimmer than *L. scorpioides*. Collett (1874, 1875a) stated that body depth in the former was contained about seven times in the standard length, but only six times in *G. scorpioides*. Holt & Byrne (1903) noted that body depth was equal to one fifth and one sixth of the total length of *G. scorpioides* and *G. orca* respectively, and referred to this apparent difference in their key to the species. Other body proportions have been used in attempts at distinguishing these fishes. Collett (1875a), Lilljeborg (1884), Smitt (1892), and Holt & Byrne (1903) all regarded the eye to be relatively larger in the head in *G. orca* than in *G. scorpioides*. A supposed difference in the position of the anus with reference to the middle of the body was utilized in a key by Smitt (1892).

The significance of these characters has been tested in the present material and the results are given in Table V and Text-fig. 1. These show that the two coloration groups cannot be distinguished by such criteria.

TABLE V.—Mean and Range of Values for Certain Body Proportions in the Two Coloration Groups

Body proportions	Coloration group					
	<i>orca</i>			<i>scorpioides</i>		
	No. of Obs.	Mean	Range	No. of Obs.	Mean	Range
(a) In standard length						
Depth at origin of pelvic fin	21	5.64	5.10-6.65	28	5.65	5.10-6.30
Depth at origin of anal fin .	23	6.50	5.90-7.30	26	6.55	5.70-7.50
Depth (least) of caudal peduncle before caudal fin origin	23	10.00	9.20-11.0	29	10.22	8.50-12.30
Distance from snout to anus	22	1.87	1.75-2.00	18	1.85	1.75-1.90
(b) In head length						
Diameter of eye	8	3.02	2.80-3.20	5	2.98	2.80-3.40

Development of the dorsal fins. Collett (1874, 1875a) reported that the first dorsal fin was considerably higher than the body in *G. orca*, but only slightly so in *G. scorpioides*. It was also stated that the first rays of the fin were produced and free from the interradiial membrane in *G. orca*. Duncker (1928) treated the latter as a feature of diagnostic value, and believed that *L. orca* differed from *L. scorpioides* in having the first dorsal fin higher than the second dorsal fin.

In the present work, fin ray length has been used as an index of fin height because the latter is difficult to measure accurately. With adults in both the *orca* and *scorpioides* groups, the second and third rays of the first dorsal fin were longer than any in the second dorsal fin, and greater than the body depth at the origin of the pelvic

fin. In length of the second ray, there was little difference between the groups (Text-fig. 2A), while for the third ray and the other rays of the first dorsal fin, as well as in the second dorsal fin, there is a more or less pronounced divergence, *orca* specimens having the longer rays. This trend is very noticeable in the last three rays of the first dorsal fin (Text-fig. 2B) and, together with corresponding growth of the interradial and posterior membranes, gives the fin a much greater spread in the *orca*

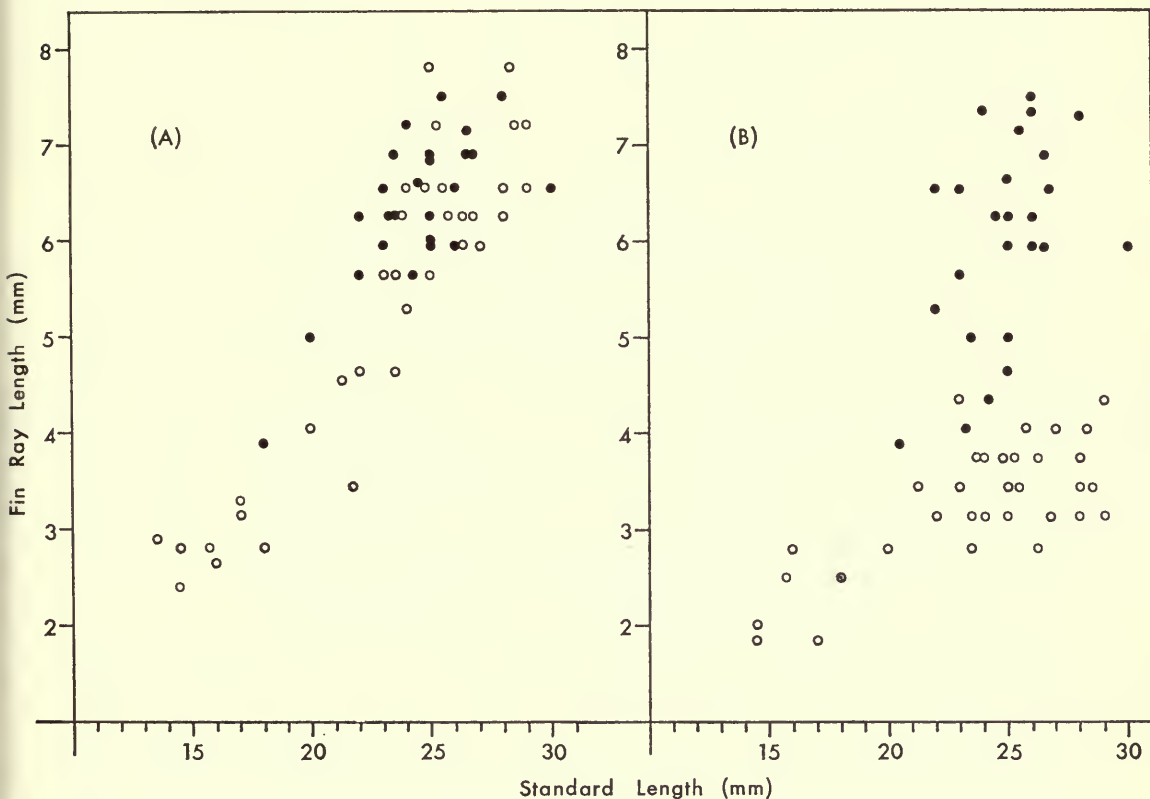


FIG. 2. Relation between standard length and lengths of certain first dorsal fin rays in the two coloration groups. (A) Second ray; (B) Fifth ray. Other symbols as Fig. 1.

individuals. In the best preserved specimens of both groups, the tips of the dorsal fin rays do not project beyond the fin membrane.

Other morphological characters. Comparison of other body proportions and anatomical features, such as patterns of sensory papillae over the head and body, does not reveal any differences between the *orca* and *scorpioides* groups.

Distribution. The two species have been recorded throughout the geographical range of the genus, which is eastern Atlantic boreal in occurrence. Thus *L. orca* and *L. scorpioides* are both reported from Iceland (Saemundsson, 1926; Tåning, 1940) and the western coast of Norway (records summarized by Grieg, 1913). In the south, they are known from the Gulf of Gascony (Collett, 1896) and Roscoff (Le Danois,

1910) respectively. It is only in Danish waters and in the western Channel, where most records are of juvenile specimens, that many individuals of one species (*L. scorpioides*) have been obtained and none of the other.

A slight divergence in habitat preference was implied by Duncker (1928) who mentioned that *L. orca* occurred on "fine to coarse sandy ground" while *L. scorpioides* inhabited "mostly hard ground (*Lithothamnion*, shelly sand, gravel)". Tåning (1940) suggested that *L. orca* was a more offshore form than *L. scorpioides*, but Le Danois (1948) listed both gobies as occurring in the "zone subcôtière" (40–100m.) and deeper parts (120–200 m.) of the continental shelf. While investigating the bottom fauna off the south of the Isle of Man, Jones (1951) encountered both *Lebetus* species on the coarser offshore grounds. The records of *L. orca* were restricted to an area of several square miles south west of the Calf Island, where the bottom is overlaid by a deposit of dead shells, chiefly *Glycimeris*. Both species were obtained by Grieg (1913) from similar bottoms in Hardangerfjord, Norway. The positions of capture for the Manx specimens collected by Jones and later workers have been plotted in Text-fig. 15, where the number of *orca* and *scorpioides* specimens are indicated by symbol at each locality from which fishes have been examined in the present work. No ecological separation is demonstrable between the two groups and, at localities where adequate material has been obtained, both *orca* and *scorpioides* appear to be represented in comparable numbers.

The bathymetric range off the Isle of Man is 18–64 m. for the *orca* group, and c.18–64 m. for *scorpioides*. Previous authors have cited depth ranges of 20–375 m. and 3·5–135 m. for *L. orca* and *L. scorpioides* respectively (Holt & Byrne, 1903; Grieg, 1913). The apparently greater penetration of deeper waters by the former species may well be due merely to lack of collecting. Pronounced contrast in bathymetric distribution between the two species remains to be established.

Conclusion. The above paragraphs indicate that the two groups to which *Lebetus* specimens may be assigned are obviously different only in coloration and in growth of the dorsal fins, especially the first. The *orca* group consists entirely of males, almost all maturing or mature, and the *scorpioides* of females and immature males. The type specimens of *Gobius orca* (ZMO J3999) and *G. scorpioides* (ZMO J4020, J4021) have been available for study, and are a male, maturing if not mature, and two females respectively. Sexual dimorphism in colour and fin ray length is a well known phenomenon among many teleosts, and has recently been discussed by Egami (1960) for Japanese gobies. It appears safe to conclude, therefore, that the two names apply to one and the same species, for which the name *orca* Collett 1874, p. 446, ranks by page priority as the senior synonym to *scorpioides* Collett 1874, p. 447.

Lebetus orca (COLLETT 1874)

(Text-figs. 3 and 4)

Gobius orca Collett, 1874: 446; 1875a: 172, pl. III, figs. 1–3; 1875b: 57; Winther, 1877: 49; Lilljeborg, 1884: 616; Smitt, 1892: 259, fig. 66; 1900: 554; Collett, 1902: 57; Holt & Byrne, 1903: 57, fig. 5; Patience, 1906: 74; Grieg, 1913: 41; Jenkins, 1925: 88, 97; Elmhirst, 1926: 154; Koumans, 1931: 47; Whitley, 1931: 155; Lönnberg &

- Gustafson, 1935 : 246, fig. 2 (photograph) ; Norman, 1935 : 58 ; Jenkins, 1936 : 88, 97, 388 ; Ehrenbaum, 1936 : 168, fig. 147 ; Andersson, 1942 : 85 ; Jones, 1949 : 28.
- Gobius scorpioides* Collett, 1874 : 447 ; 1875a : 175, pl. III, figs. 4-6 ; 1875b : 58 ; Lilljeborg, 1884 : 620 ; Smitt, 1892 : 260, fig. 67 ; Holt & Byrne, 1898 : 337 ; Grieg, 1899 : 7 ; Smitt, 1900 : 554 ; Collett, 1902 : 59 ; Holt & Byrne, 1903 : 56, pl. II, figs. 2 and 3 ; Aflalo, 1904 : 158 ; Holt & Byrne, 1910 : 7 ; Crawshay, 1912 : 300, 385 ; Farran, 1912 : 2, 3 ; Otterstrøm, 1912 : 162 ; Grieg, 1913 : 43 ; Clark, 1914 : 372 ; Petersen, 1917 : 10, 13, 14 ; Fage, 1918 : 63, 71, 101, figs. 54-56 ; Jordan, 1919 : 392 ; Jenkins, 1925 : 88, 96, pl. 30, figs. 2 and 3 ; Johansen, 1925 : 5, 6, 10, fig. 6 ; Saemundsson, 1926 : 178 ; 1927 : 19 ; Koumans, 1931 : 43, 46 ; Whitley, 1931 : 155, 156 ; Lönnberg & Gustafson, 1935 : 247 ; Norman, 1935 : 58 ; Jenkins, 1936 : 88, 96, 388, pl. 30, figs. 2 and 3 ; Ehrenbaum, 1936 : 168 ; Andersson, 1942 : 85 ; Jones, 1949 : 28 ; Went, 1957 : 18.

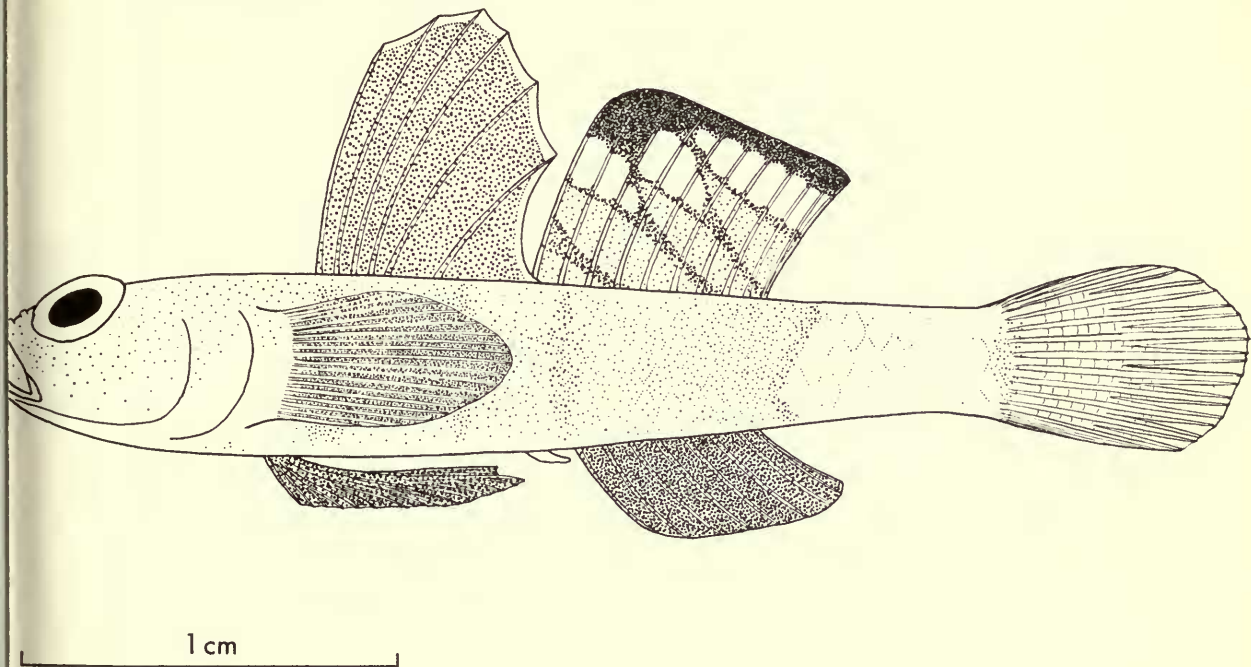


FIG. 3. *Lebetus orca* (Collett), mature male.

- Lebetus scorpioides* Winther, 1877 : 49 ; Malm, 1877 : 651 ; Winther, 1879 : 18 ; Petersen, 1919 : 48, 49, 55, 59, 61, pl. I, figs. 27-29, pl. III, fig. 4 ; Clark, 1920 : 226, 232 ; Russell, 1926a : 134, 152-153, 155-157 ; 1926b : 397, 411 ; Duncker, 1928 : 141, fig. 13 ; Ehrenbaum *et al.*, 1929 : 155 ; Iljin, 1930 : 55, fig. 43 ; De Buen, 1930a : 125 ; 1930b : 6, 21, 27, figs. 9 and 10 ; Russell, 1930a : 661, 672 ; 1930b : 708, 713, 718 ; De Buen, 1931 : 50 ; Marine Biological Association, 1931 : 324 ; De Buen, 1932 : pl. 300 ; Russell, 1935 : 153, 154 ; 1936 : 604 ; 1939 : 386 ; Bal, 1940a : 82, 86 ; 1940b : 16 ; Russell, 1940 : 270 ; Tåning, 1940 : 279 ; Brunn & Pfaff, 1950 : 50 ; Jones, 1950 : 31 ; 1951 : 137, 144 ; Cantacuzene, 1956 : 41 ; Marine Biological Association, 1957 : 401.
- Lebetus orca* Collett, 1885 : 61, pl. I, figs. 1 and 2 ; 1896 : 41 ; Duncker, 1928 : 142, fig. 14 ; De Buen, 1930a : 125 ; 1930b : 21, 23, 27 ; 1931 : 50 ; Tåning, 1940 : 277, 282 ; Saemundsson, 1949 : 38, 136 ; Bruun & Pfaff, 1950 : 50 ; Jones, 1950 : 31 ; 1951 : 137, 144.
- Gobius jeffreysii* Günther, 1888 : 210 (*partim*), pl. III, fig. 3 (*non* Günther, 1867 : 290, pl. V, fig. c).

Gobius (Lebetus) scorpioides Smitt, 1900 : 554 ; Le Danois, 1910 : 168, figs. 4 and 5 ; 1948 : 279 ; 953 : 136 and facing pl., 184.

Gobius (Lebetus) scorpioides guiletti Le Danois, 1913 : 91, 160, 161, 169, 186, 189, figs. 159-161.

Gobius (Lebetus) orca Le Danois, 1948 : 121, 279.

Gobius sp. Schmidt, 1904 : 53 ; Saemundsson, 1908 : 32.

TYPE SPECIMENS. The holotype of *Gobius orca* (ZMO J3999) is a male from Espevaer, Hardangerfjord, Norway, dredged in 145-180 m. during July 1873. The two syntypes of *Gobius scorpioides* (ZMO J4020, J4021) are females from Hvittingsô, Stavangerfjord, and Lyngholmen, Hardangerfjord, dredged in 37 and 110 m., during July 1872 and August 1873 respectively. In condition, these specimens are now somewhat shrunken, and the caudal fin in each one has been cut off by an earlier investi-

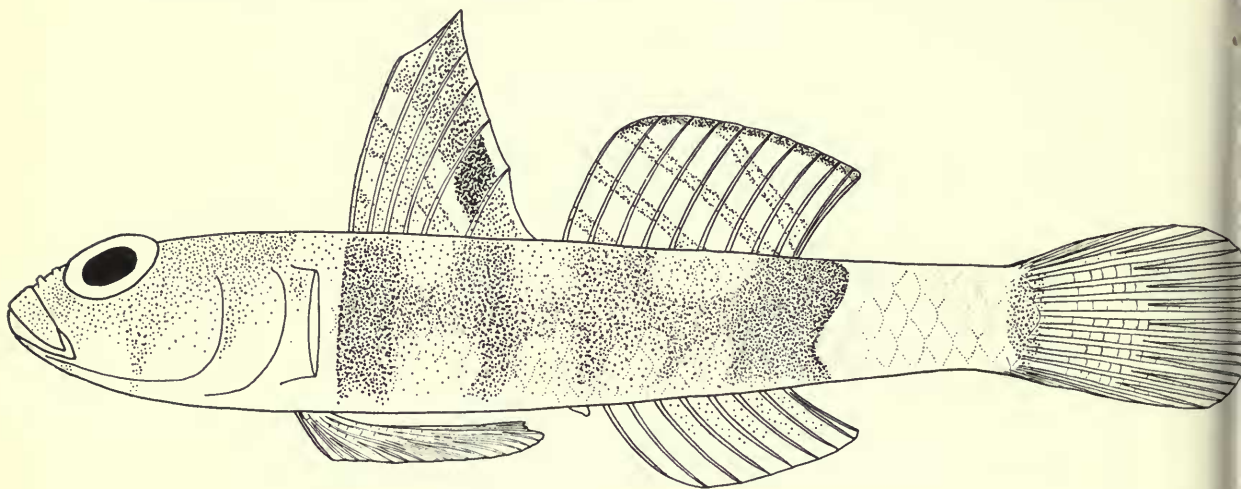


FIG. 4. *Lebetus orca* (Collett), mature female. Pectoral fin removed to show body markings.

gator. Present lengths, original lengths (Collett, 1874, 1875a) and meristic values are given in Table VI.

TABLE VI.—*Present Lengths, Original Lengths (Collett, 1874, 1875a, b) and Meristic Values for Type Specimens of Gobius orca and G. scorpioides.* d = *Damaged*

Sex	ZMO No.	Lengths (mm.)		Meristic values				
		Original standard +Caudal fin	Present standard	First Dorsal	Second dorsal	Anal	Pect- oral	Scales in l.l.
♂	J 3999	26.0+6.0	25.0	d.	1/10	1/8	d.	26-27
♀	J 4020	total 28.0	21.5	VI	1/9	1/7	d.	d.
♀	J 4021	30.0+7.0	29.0	VI	1/9	1/7	20	27-28

GENERAL DESCRIPTION. Body subcylindrical, laterally compressed towards caudal fin; in standard length, depth at origin of pelvic fin 5.1-6.65 (mean 5.65), at origin of anal fin 5.7-7.5 (6.53), of caudal peduncle before origin of caudal fin 8.5-12.3 (10.12). Head rounded; in standard length, horizontal length (snout to upper origin of opercle) 3.2-4.1 (3.71), maximum width (between upper origins of opercles) 5.25-5.95 (5.68). Horizontal distance from tip of snout to origin of first dorsal fin 2.7-3.05 (2.9), to origin of second dorsal fin 1.7-1.9 (1.81), to anus 1.75-1.95 (1.86), to origin of anal fin 1.6-1.75 (1.69), to origin of pelvic fin 3.2-4.0 (3.47), all in standard length. Caudal peduncle (end of anal fin base to origin of caudal fin) horizontal length 4.15-5.1 (4.71) in standard length, depth 1.8-2.35 (2.07) in own length. In head length, snout 3.8-5.6 (4.7), eye 2.8-3.4 (3.0), postorbital length 2.0-2.7 (2.34), cheek 3.8-4.85 (4.34); eye and cheek direct, rest horizontal measurement. Interorbital minimum width (bony) 4.3-7.4 (5.5) in eye length. Snout less than diameter of eye, with moderately sloping profile; nostrils adjacent, anterior on short tube, not projecting over upper lip and with entire distal rim lacking local prolongation; posterior nostril also tubular but shorter. Eyes large, close together. Postorbital region never exceeding half head length; profile more or less flat, without dermal ridges. Upper jaw relatively wide, about equal to preorbital area. Mouth oblique, lower jaw at most only slightly in advance of upper; maxilla ends posteriorly under anterior quarter of eye. Lower jaw unarmed, without barbels. Cheek smooth, without dermal ridges. Preopercle unarmed. Branchiostegous membrane attached to entire lateral margin of isthmus from immediately anterior to lower edge of pectoral lobe and without transverse fusion across isthmus (Text-fig. 5). Teeth simple, caniniform, erect in both jaws. Dentition of jaws an outer row of larger teeth with narrow band of two to four rows of smaller teeth. Pharyngeal teeth relatively large, recurved, in two superior and one inferior median patch (see description of skeleton). Tongue more or less truncate, with anterior edge rounded laterally; at most pronounced, a very slight median emargination (Text-fig. 6B). Gill rakers small protuberances, not spinous, about 6-8 on first arch. Sagittal otolith rectangular, anterior and posterior edges slightly concave, inferior edge slightly convex, superior edge with angular projection near posterior end; outer surface convex, more flattened in middle, inner surface convex, with furrow in middle and shallower groove to posterior edge (Text-fig. 6A).

FINS. In the following counts, spinous elements are represented by large roman, articulated rays by arabic numerals. The terminal bifid ray in the second dorsal and anal fins is counted as one element. Only in the caudal and pelvic fins are articulated rays branched. The range of values is given in parentheses after the most common number, frequency distribution being shown in Table VII.

First dorsal fin VI (VI-VII); second dorsal fin I/9 (6-11); anal fin I/7 (5-8); caudal fin (branched rays) 9 (8-10); pectoral fin 19 (15-21), pelvic fin I/5 + I/5. In standard length, first dorsal base 7.95-8.95 (8.24), second dorsal base 3.75-4.55 (4.24), anal base 4.85-5.8 (5.4), longest caudal ray 3.2-4.45 (for standard lengths up to 20.0 mm., mean = 3.55; more than 20.0 mm., mean = 3.92), longest pectoral ray 3.7-4.45 (4.0), pelvic origin to tip of fifth pelvic articulated ray 3.85-4.55 (S.L. up to 25 mm., mean = 4.05; more than 25.0 mm., mean = 4.2). First dorsal fin

TABLE VII.—*Meristic Characters of Lebetus orca: Number of Observations against Value*

Locality	First dorsal fin rays						
	5	6	7				
British Isles .		60					
Scandinavia .	13		1				
Second dorsal fin articulated rays							
	6	7	8	9	10	11	
British Isles .	1	2	5	39	13		
Scandinavia .			2	9	4	1	
Anal fin articulated rays							
	5	6	7	8	9		
British Isles .	3	3	41	13			
Scandinavia .	1		9	5			
Pectoral fin rays							
	15	16	17	18	19	20	21
British Isles .	1	4	9	24	50	25	1
Scandinavia .				7	8	4	
Caudal fin branched rays							
	8	9	10	11			
British Isles .		2	55	2			
Scandinavia .			7				
Scales in lateral series							
	25	26	27	28	29		
British Isles .	3	35	27	12	3		
Scandinavia .	1	4	3	3			
Vertebrae including urostyle							
	26	27	28	29			
Isle of Man .	1	5	30	1			

TABLE VIII.—*Dorsal Fin Ray Lengths Expressed in Standard Length for Mature and Immature Lebetus orca*

	First dorsal fin						Second dorsal fin	
	I	II	III	IV	V	VI	I	I
Mature ♂♂ .	3·85-	3·40-	3·35-	3·20-	3·25-	4·15-	4·35-	4·10-
	5·20	4·35	3·95	3·95	4·70	5·90	5·80	4·90
Mature ♀♀ .	4·95-	3·20-	3·95-	5·40-	6·35-	9·50-	6·40-	5·75-
	6·50	4·50	5·30	7·25	9·35	13·50 (21·0)	8·25	7·05
Immature ♂♂ .	4·65-	3·65-	4·00-	4·95-	5·30-	7·25-	6·05-	5·90-
	6·80	6·05	6·05	6·80	9·10	13·60	9·20	7·25
Immature ♀♀ .	6·05-	4·15-	4·45-	5·40-	7·00-	11·00-	6·80-	5·40-
	9·35	6·40	5·80	7·15	8·50	14·40	8·50	7·00

commences behind vertical of pelvic origin, last ray arising well before vertical of anus. In standard length, dorsal fin ray lengths as in Table VIII (see also Text-figs. 19 and 20). None of dorsal rays prolonged beyond interradial membrane. In most males, no dorsal interspace, posterior membrane of first dorsal reaching origin of second dorsal fin, sometimes extending to one side of first element of latter. In females and some immature males, a short dorsal interspace. Second dorsal fin begins over or just behind vertical of anus, finishes opposite posterior end of anal fin. Anal fin commences below first elements of second dorsal fin, and ends below last element of latter. In standard length, spinous ray 8.75–10.4 (males), 10.45–12.85 (females); first articulated ray

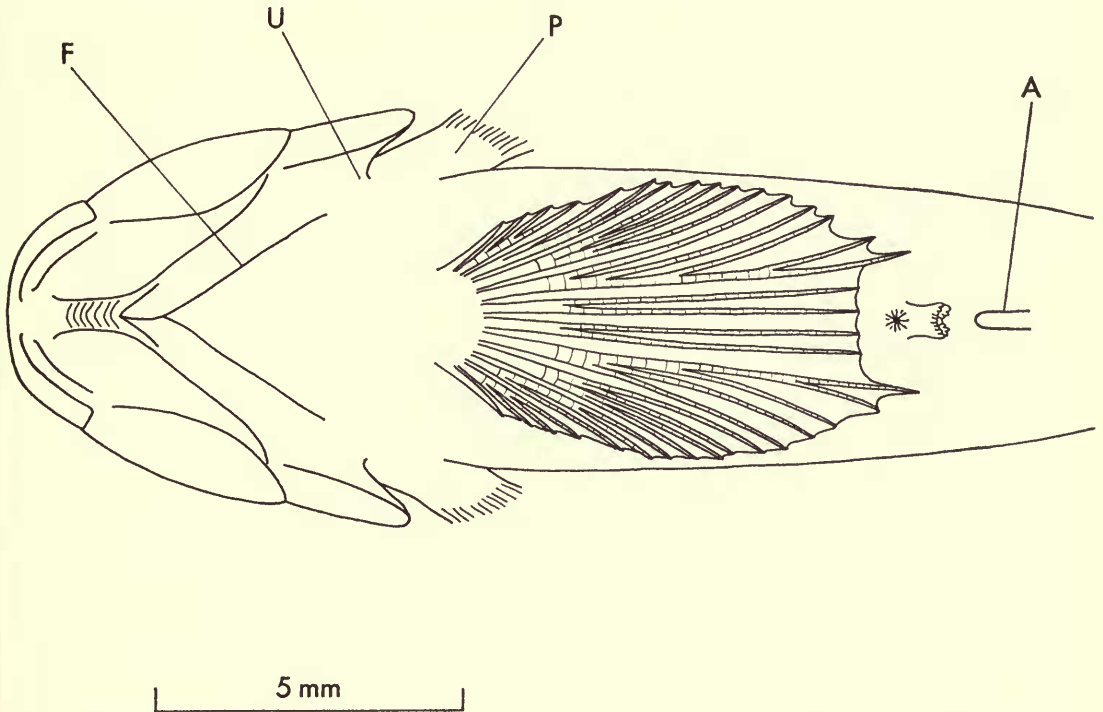


FIG. 5. Ventral view of female *L. orca*. F, fold of attached branchiostegous membrane; U, origin of branchiostegous attachment to isthmus; P, pectoral fin; A, anal fin.

6.65–8.95 (males), 8.2–10.7 (females); penultimate ray 7.1–9.7 (males), 9.2–12.45 (females). Caudal fin with rounded margin, convex posteriorly. Pectoral fin extends back to opposite anus; uppermost pectoral rays not separated from fin membrane; no dermal flaps on anterior edge of pectoral girdle. Pelvic fins not adnate, completely united along their length but with anterior membrane between spinous rays entirely absent; fourth articulated ray somewhat prolonged, terminating lateral to anus or genital papilla, but fifth ray ending immediately before anus (Text-fig. 5).

SCALES. Behind vertical of anus, body covered with large imbricating ctenoid scales; anteriorly, ctenoid scales present in narrow belt on lateral midline forward

to axilla. Lateral series 26-27 (25-29), transverse series (anterior end of second dorsal backwards to anal fin) 7 (see Table VII). Scales absent from head, predorsal region, upper part of body lateral to first dorsal and origin of second dorsal fin, pectoral lobe, axilla, isthmus, breast, and abdomen. Midline scales of caudal peduncle hexagonal,

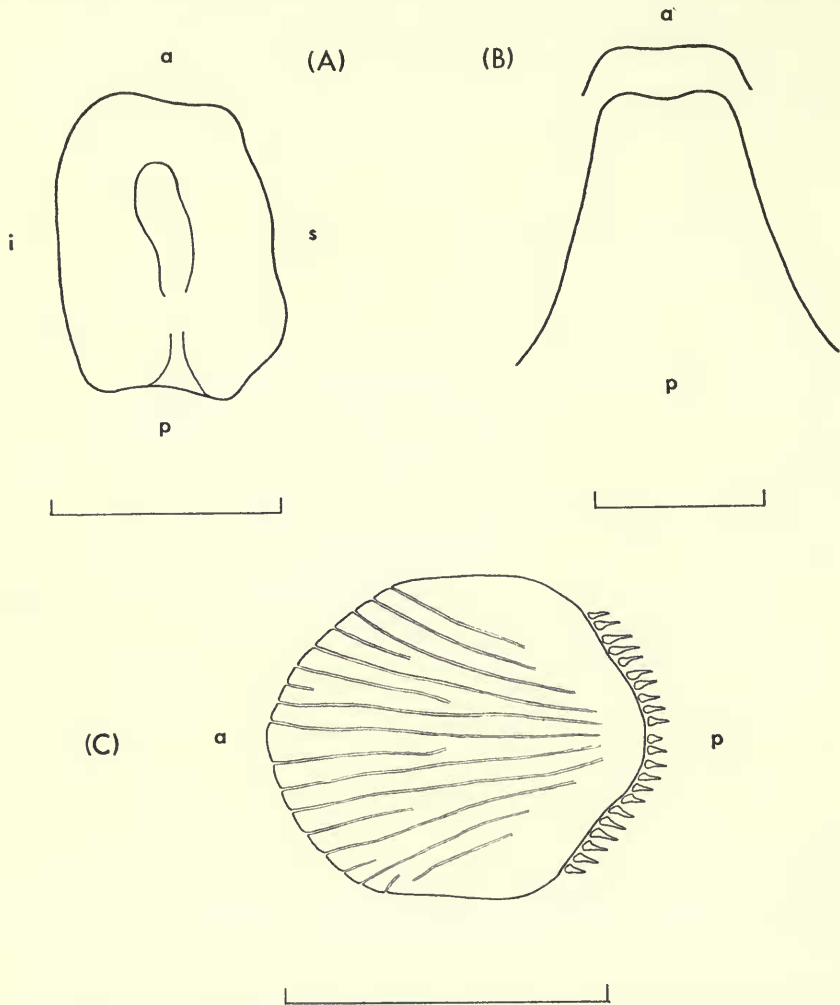


FIG. 6. *L. orca*: (A) Sagittal otolith, median view, (B) Tongue, showing extremes of variation in shape of anterior edge. (C) Scale from caudal peduncle (sclerites omitted). a, anterior; p, posterior; s, superior; i, inferior. Scale with each figure 1 mm.

somewhat elongate, with about 20 ctenii (Text-fig. 6c); scales at base of caudal fin without elongate lateral ctenii.

VERTEBRAE. Usually 28 (26-29), including urostyle (Table VII).

COLORATION. Basic pattern of more or less well developed vertical bars; first and widest below anterior part of first dorsal fin, second below posterior end of first

dorsal, third below anterior end of second dorsal, and fourth a curved mark across caudal peduncle posterior to termination of second dorsal and anal fins. Bars tend to be connected along lateral midline by denser pigment but, nearer dorsal and ventral edges of body, are separated by paler areas. Caudal peduncle from fourth bar to origin of caudal fin almost colourless with some pale yellowish or ferruginous mottling in life; a vertical dark mark across origin of caudal fin.

(a) Mature male (Text-fig. 3 and Pl. I). Body yellowish or more dusky grey; bars greyish, somewhat less well marked than in female, (especially after preservation, c.f. Text-fig. 3 and Pl. I) but posterior edge of caudal peduncle bar clearly defined in life and caudal peduncle more or less colourless. Head yellowish to reddish grey above; underside of head, cheeks, isthmus, and breast suffused with reddish orange. First dorsal fin dusky yellow, edged with white. Second dorsal fin with intense black edge, especially wide anteriorly on distal part of first two interradiial membranes, and broad oblique yellow bands separated from edge and one another by white bands, which, excepting posterior band, usually become narrower and greyish towards base of fin (wide bands to base of second dorsal shown in Pl. I are exceptional). Anal fin dusky, without white edge. Pectoral and pelvic fins dark; pectoral suffused with orange red proximally, being most intense over bases of lower pectoral rays. Caudal fin usually clear, or with traces of yellow or red.

(b) Mature female (Text-fig. 4). Body pale brown; vertical bars conspicuous purplish brown with anterior edge of first and posterior edge of caudal peduncle bar sharply defined; fusion and irregularity of intermediate bars may produce effect of coarse mottling, and sometimes a pale transverse band lies across origin of first dorsal fin between level of pectoral bases and anterior edge of first vertical bar. Head pale brown, reddish or ferruginous above; reddish brown vertical marks across cheek and immediately behind preopercle; red striae on underside of head across mental region, at angle of jaw, and below eye. First dorsal fin with oblique yellow to orange red bands each bordered with black and tending to coalesce across middle interradiial membranes; uppermost band wider, darkening posteriorly to form more or less well defined spot on distal part of last interradiial membrane; edge of fin membrane may be whitened especially adjacent to spot. Second dorsal fin with narrow dark edge, and four narrow oblique bands of orange red, each bordered with black, across hyaline fin. Caudal, pectoral, and pelvic fins usually hyaline; a reddish brown mark on upper part of pectoral lobe. Anal fin pigmented on proximal areas of posterior interradiial membranes.

(c) Immature fishes. Both sexes resemble mature female. First dorsal fin of males usually more uniform in colour but may show bands and spot; second dorsal fin with conspicuous dark spot at distal end of first and second interradiial membranes, as well as rather wider oblique bands and more intense dark edge. In youngest individuals, pelvic and anal fins black, and dark vertical bar across pectoral fin; underside of head, isthmus, and breast covered with melanophores, which later disappear.

LATERAL LINE SYSTEM. Terminology and lettering of the sensory papillae in the present text and diagrams follow the system invented by Sanzo (1911). As part of the general reduction in number of papillae, in certain cases only one or at most a

few papillae occur in areas where a well defined row or rows are found in the genera described by Sanzo. Under these circumstances, it is not possible to be sure of the exact homologies of the papillae in *Lebetus* so that in some instances composite lettering has been adopted.

(a) Cephalic canals. These are absent.

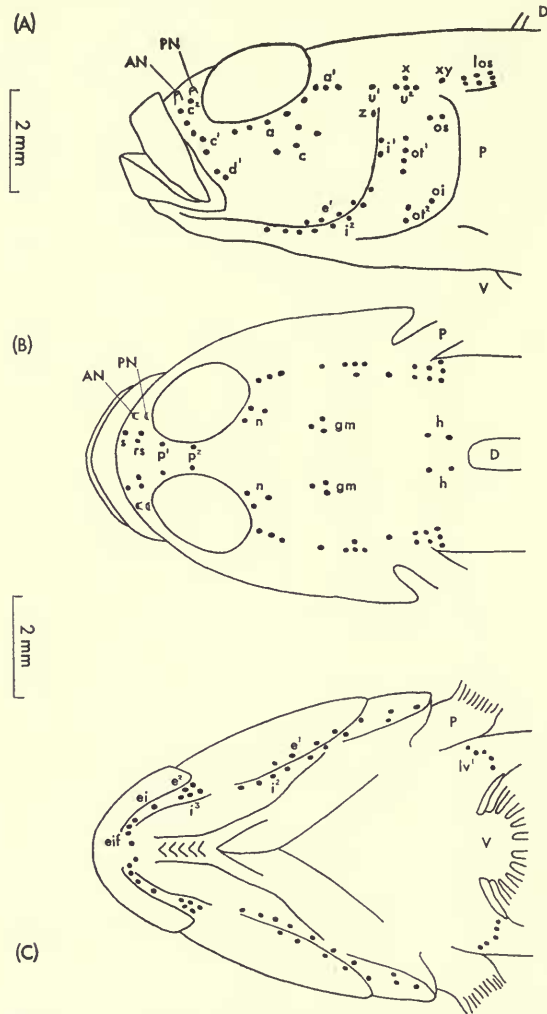


FIG. 7. Sensory papillae of head in *L. orca*. (A) Lateral, (B) Dorsal, (C) Ventral views. AN, anterior nostril; PN, posterior nostril; D, first dorsal fin; P, pectoral fin; V, pelvic fin. Other abbreviations as in text.

(b) Sensory papillae. Relatively large, and easily seen. Numbers of papillae are given in parentheses.

(i) Preorbital (Text-figs. 7A, 7B). Median series in two parts, anterior *s* (1) and posteriorly *rs* (2, inner sometimes absent); another papilla rarely present between

rs and p^1 of interorbital series. Lateral series c^1 (5) and c^2 (1), the latter rarely present.

(ii) Suborbital (Text-fig. 7A). Infraorbital row *a* (5) continued as a^1 (3) into oculoscapular groove. Longitudinal row *c* (2-3, rarely 4). Between rows *a* and *c* a single papilla, probably referable to *c*. Row *b* absent. Row *d* represented by d^1 (2), without horizontal posterior section.

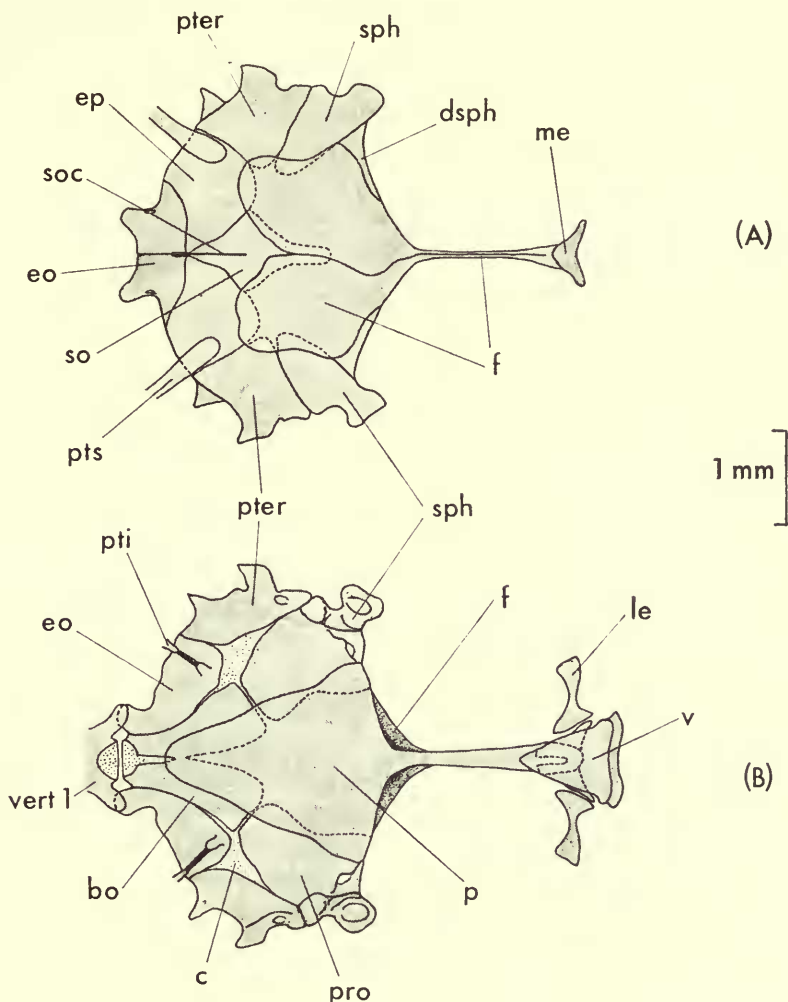


FIG. 8. Neurocranium of *L. orca*. (A) Dorsal, (B) Ventral views. Abbreviations as in text.

(iii) Preoperculo-mandibular (Text-figs. 7A, 7C). External row *e* in two parts, posterior e^1 (3-4, rarely 5), and anterior e^2 (2-3). Internal row *i* in three parts; superior i^1 (2), posterior i^2 (7-8), and anterior i^3 (2-3). A single papilla *ei* usually present halfway between angle of jaw and mental region. Mental row *eif* (2-4).

(iv) Oculoscapular (Text-fig. 7A). Longitudinal row *u* of oculoscapular groove in two parts, anterior u^1 (1), and posterior u^2 (3). One papilla *z* anterior to commence-

ment of preopercular groove, another x over u^2 , and a third xy above border of opercle. Axillary series las in three vertical rows (2; 2; and 2-3, rarely 4, respectively).

(v) Opercular (Text-fig. 7A). Transverse row ot in two parts, upper ot^1 (4, very rarely 5) and lower ot^2 (2); superior longitudinal row os (2); and inferior longitudinal row oi (1).

(vi) Anterior dorsal (occipital) (Text-fig. 7B). Three groups, anterior n (3, rarely 4), middle gm (3), and posterior h (2).

(vii) Interorbital (Text-fig. 7B). Two papillae, anterior p^1 and posterior p^2 ; former occasionally absent.

(viii) Trunk (not illustrated except lv^1). Three series; superior with ld^1 (1-2) flanking first dorsal fin near origin, ld^2 (2) near posterior membrane of first dorsal fin, and ld^3 (3) on caudal peduncle near origin of caudal fin; median with about nine or ten short transverse rows ltm^1 to ltm^9 or 10 (first usually 4, rest 3 each) along midline to origin of caudal fin; inferior with lv^1 (4-8) between origins of pelvic and pectoral fins (Text-fig. 7C), lv^2 of one, rarely two, lateroventral rows on abdomen (3-4 each), and lv^3 (2) just before anus.

(ix) Caudal (not illustrated). Three papillae around posterior edge of last scale of midline which overlaps base of caudal fin, and up to 12 papillae, from middle papilla of former group, in line on interradiial membrane to near posterior edge of fin. Sometimes a parallel series on membrane below.

SKELETON. This is well ossified.

(a) Neurocranium (Text-figs. 8, 9). (i) Proportions. Postorbital region broad, slightly wider than long, depressed; interorbital septum strongly compressed especially in dorsal aspect; preorbital region small.

(ii) Occipital bones. Basioccipital (bo) with broad forks truncate anteriorly, articulating posteriorly with centrum of first vertebra (*vert.* 1). Exoccipital (eo) carrying posteriorly stout articular process opposed to upper surface of prezygapophysis of first vertebra, extending ventrally along side of skull with knob near distal end to which inferior limb (pti) of posttemporal is attached by strong ligament, and dorsally in contact with fellow behind supraoccipital. Supraoccipital (so) relatively large, diamond shaped, bearing prominent crest (soc), which is triangular with emarginate posterior edge and pointed apex and continues backwards on to anterior part of exoccipital area.

(iii) Otic bones. Sphenotic (sph) at anterior corner of neurocranium produced into horizontal flange for articulating with hyomandibular, and with wide posterior extension separated from epiotic; a dermosphenotic element ($dsph$) forms part of posterior border of orbit, firmly attached to sphenotic proper. Pterotic ($pter$) forming posterior corner of neurocranium with articular surface on ventral face for hyomandibular. Epiotic (ep) large, in contact with superior limb (pts) of posttemporal, approaching fellow in dorsal midline but separated by posterior end of supraoccipital. Prootic (pro) broad, meeting basioccipital. No opisthotic, but on ventral surface of neurocranium, a cartilaginous area (c) bounded by prootic, pterotic, exoccipital, and to a slight extent by basioccipital.

(iv) Preorbital neurocranium. Mesethmoid (me) with cartilaginous body, ossified

as posterior vertical lamina at anterior corner of interorbital space surmounted by triangular ossification, from whose anterior end a thin, dorsally concave plate extends forwards over cartilage towards vomer, and with lateral ossified area adjacent to lateral ethmoid. Vomer (*v*) consisting of well ossified transverse bar across anterior end of ethmoid cartilage with thin scale of bone extending backwards over ventral surface of ethmoidal region and end of parasphenoid. Lateral ethmoid (*le*) attached to side of ethmoid cartilage; proximal part of upper surface and adjacent mesethmoid forming articular surface for ethmoidal head of palatine, and, laterally, alate in border of orbit. Prefrontal (*pf*) falciform, attached to anterior face of lateral ethmoid wing and distally related to maxilla.

(v) Other dermal bones. Frontal (*f*) large, overlapping sphenotic, pterotic, epiotic, and supraoccipital, ending anteriorly below posterior edge of mesethmoid. No parietal. Parasphenoid (*p*) large triangular plate covering edges of basioccipital

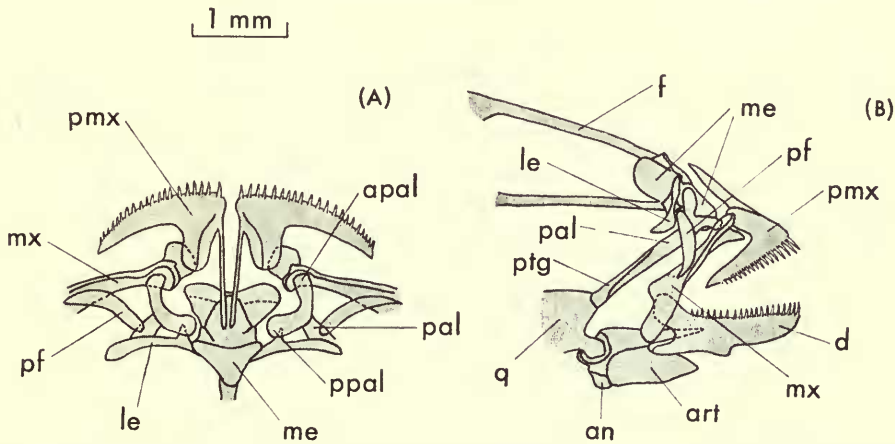


FIG. 9. Preorbital cranium of *L. orca*. (A) Dorsal, (B) Lateral views. Abbreviations as in text. Note that only outer row of teeth is shown on premaxilla and dentary.

and prootic with anterior process terminating below mesethmoid and above vomer. Between orbits, frontals and parasphenoid much compressed, forming upper and lower boundaries of interorbital septum, which is otherwise unossified save for mesethmoid lamina. Nasals and suborbitals absent.

(b) Branchiocranium (Text-figs. 9, 10, 11). (i) Suspensorium. Hyomandibular (*h*) broad, with two heads; anterior head articulating with lateral flange of sphenotic, posterior head with anterior end of ventral face of pterotic; posteriorly, strong stay on inner face articulating with operculum; posteroventrally, sword-shaped process extends over upper end of preoperculum. Symplectic (*sy*) a slender bone running along lower anterior corner of hyomandibular to inner surface of quadrate almost to angle of jaw. Metapterygoid (*mpt*) elongate, along anterior edge of hyomandibular and symplectic but not reaching quadrate. Quadrate (*q*) with anterior triangular part bearing articulation for lower jaw at inferior corner; a broad curved blade produced backwards from posterior edge and applied to inner face of preoperculum.

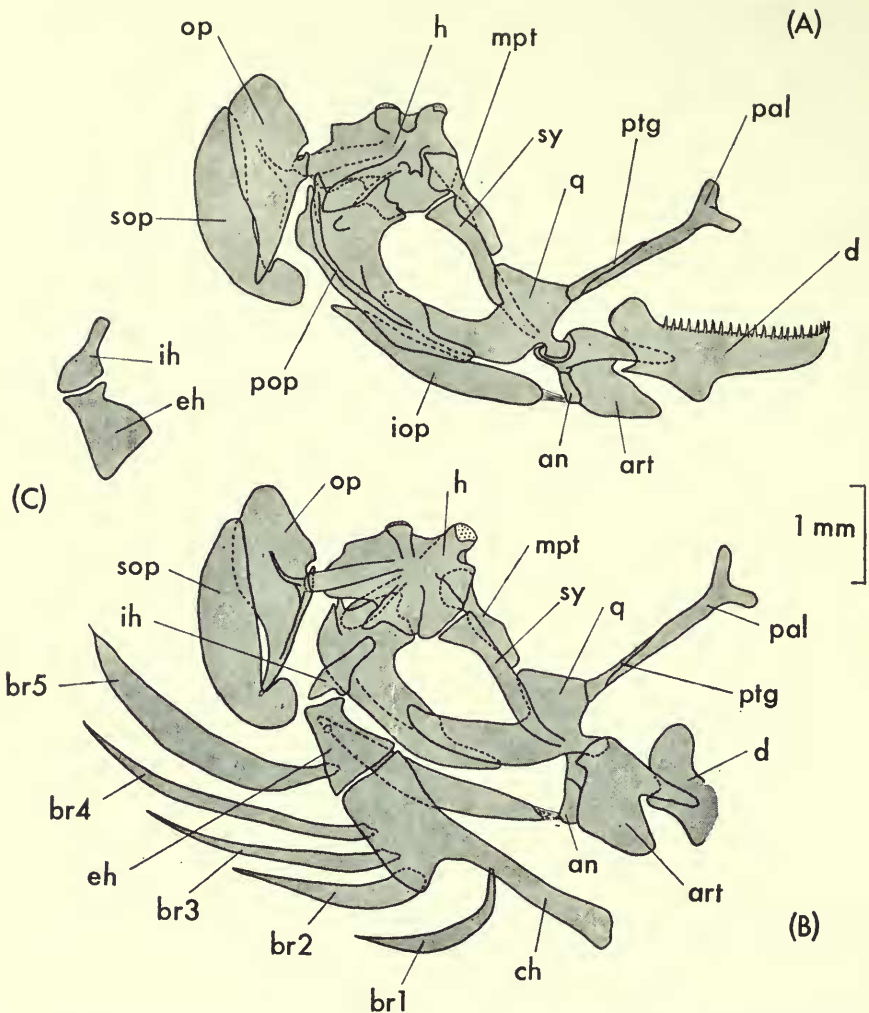


FIG. 10. Suspensorium of *L. orca*. (A) Lateral, (B) Median views. (C) Interhyal and epihyal bones, median aspect. Abbreviations as in text.

Preoperculum (*pop*) an integral part of suspensorium with strongly ridged posterior edge; upper part of wide anterior lamina firmly united with hyomandibular over wide area. Between preoperculum, symplectic, and quadrate exists a wide oval non-osseous foramen.

(ii) Palatopterygoid arch. Consists of two bones, pterygoid (*ptg*) a posterior splint applied to upper anterior corner of quadrate and lying along lower part of palatine, and palatine (*pal*) larger, anterior end with two heads, posterior head (*ppal*) articulating with ethmoid region, anterior (*apal*) with posterior face of proximal end of maxilla.

(iii) Upper jaw. Maxilla (*mx*) bearing outer ridge; distal end blunt with rounded

posterior margin; proximal end with anterior lamina below posterior extension of premaxilla, and accommodating behind the anterior head of palatine. Premaxilla (*pmx*) pointed distally; at proximal end, posterior tongue overlies process of maxilla; medially, a long laterally compressed rod ascends over mesethmoid and together with fellow is embedded in oval plate of cartilage (not illustrated) related to mesethmoid groove. Premaxilla toothed along entire anterior edge.

(iv) Lower jaw. Articular (*art*) with large ventral plate. Angular (*an*) small, at posterior corner of articular. Dentary (*d*) toothed along upper edge anterior to relatively small blunt coronoid process.

(v) Hyoid arch. Consists of relatively large interhyal (*ih*), broad epihyal (*eh*), and large ceratohyal (*ch*) abruptly narrowing halfway along its length. Hypohyal (*hh*)

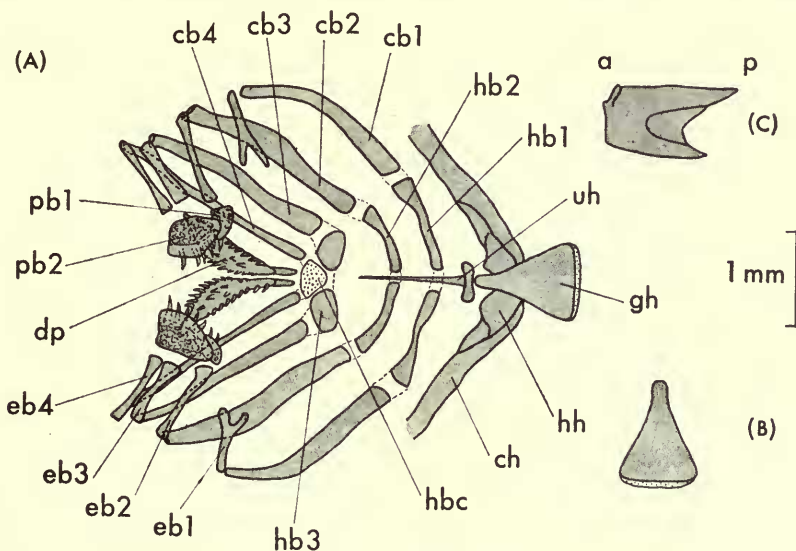


FIG. 11. *L. orca*: (A) Branchial skeleton, dorsal view. (B) Glossohyal, dorsal view. (C) Urohyal, lateral view. a, anterior; p, posterior. Other abbreviations as in text.

firmly applied to anterior end of ceratohyal. Glossohyal (*gh*) fan shaped with straight anterior edge (Text-fig. IIB). Urohyal (*uh*) a vertical lamina with strongly emarginate posterior edge (Text-fig. IIC).

(vi) Branchial arches. Pharyngobranchials (*pb* 1, 2) represented by two dentigerous plates, the more posterior much larger and overlapping anterior one, opposite medial end of last three epibranchials. Epibranchials (*eb*) four, first one forked. Ceratobranchials (*cb*) four. Ventrally, first two hypobranchials (*hb* 1, 2) distinct; a small round ossification (*hb* 3) in position of third, and a median cartilaginous plate (*hbc*) related to lower ends of fourth ceratobranchials. Fifth branchial arch represented by ventrolateral subtriangular dentigerous plate (*dp*) approaching fellow but separated in ventral midline. Ossified basibranchials absent.

(vii) Opercular series. Operculum (*op*) and suboperculum (*sop*) somewhat vertically elongate. Interoperculum (*iop*) long, anteriorly connected to angular by strong

ligament, posteriorly to outer face of epihyal near articulation of latter with interhyal. Branchiostegous rays (*br* 1-5) five, uppermost and broadest attached to epihyal, next three to broad part of ceratohyal, and lowest and shortest to narrow section of ceratohyal.

(c) Pectoral Girdle (Text-fig. 12A). Cleithrum (*cl*) large, slightly bifid at upper end, in contact with fellow in ventral midline; at level of hypocoracoid, broad triangular process (Text-fig. 12B, *ctp*) meets pelvic element. Cleithrum joined by small supra-cleithrum (*scl*) to posttemporal (*pt*), which has two well developed anterior arms, with upper, stronger, to epiotic (*pts*), and lower, more slender, to exoccipital (*pti*). No hypercoracoid. Hypocoracoid (*hc*) small, at lower end of vertical part of cleithrum.

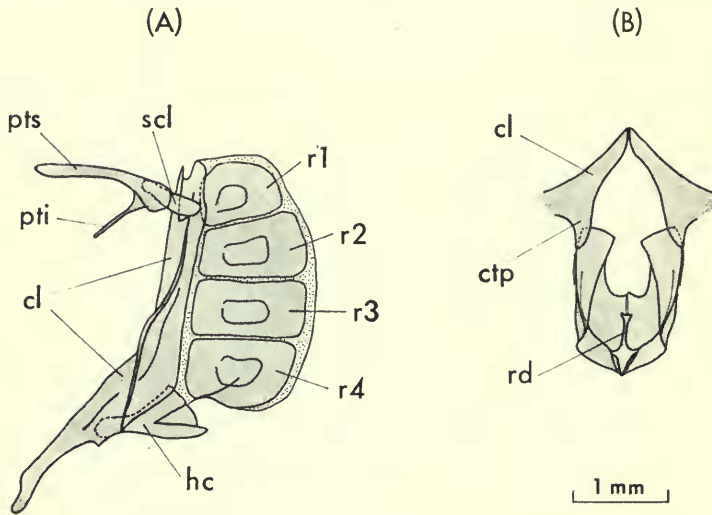


FIG. 12. *L. orca*: (A) Pectoral girdle, lateral view. (B) Pelvic girdle, ventral view. Abbreviations as in text.

Radials (*r* 1-4) large plates set in cartilage lamina attached along median side of posterior edge of cleithrum, with lower corner of most inferior radial joined by cartilage to upper part of posterior edge of hypocoracoid.

(d) Pelvic girdle (Text-fig. 12B). Each innominate bone consists of stout lateral section curving medially to form with fellow the posterior lip of girdle on which pelvic rays articulate except at median blunt protuberance, and a wide lamina arching dorsally and medially to join that from opposite side along median longitudinal suture. At posterior apex of girdle, a rod of bone (*rd*) with expanded base projects forwards ventral to lamina. Broad anterior ends of innominate bone related along lateral edge to median face of triangular process (*ctp*) from cleithrum (*cl*) of pectoral girdle.

(e) Axial skeleton. Vertebrae usually 27 (excluding urostyle); first five centra progressively shorter towards occiput, with first two shorter than wide. Third to thirteenth inclusive carry pleural ribs; twelfth to last complete vertebra with closed

haemal arches; first sixteen bear epipleurals. Last two epipleurals only ossified distally; in preceding two, ossified in two parts.

(f) Caudal skeleton (Text-fig. 13). Two large hypurals (*hyp*), upper fused to urostyle; along upper and lower edges of hypural fan lie splintlike epaxial (*epr*) and hypaxial (*hyr*) caudal radials. Lying freely between upper hypural and expanded neural arch of last vertebra occurs large roughly triangular epural plate (*epu*). Ventrally this may bear vestige of neural arch (*vna*), another part of which (*vnb*) occurs on anterior half of urostyle (*ur*). Neural (*nsp*) and haemal spines (*hsp*) of last three or four vertebrae are progressively expanded towards urostyle; on fusion of neural arch with postzygapophysis, root of arch comes to lie along whole length of centrum. Similar spread of haemal arches. Minor abnormalities found in caudal skeleton

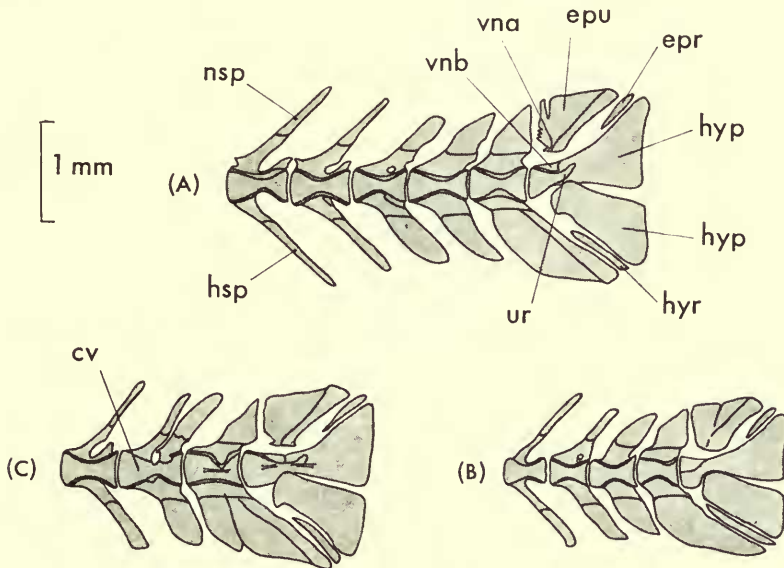


FIG. 13. Caudal skeleton of *L. orca*. (A) Normal. (B) Without vestigial neural arch. (c) With complex vertebra. Abbreviations as in text.

include loss of vestigial neural arch (*vna*, *vnb*), and a complex vertebra (*cv*), shown in Text-figs. 13B, C.

BIOLOGY

GEOGRAPHICAL DISTRIBUTION (Text-fig. 14). The genus *Lebetus* seems to be restricted to the European Atlantic boreal region, as defined by Ekman (1953). Outside the broad limits of this area, there are a few records of larval fishes from the Straits of Gibraltar, doubtfully assigned to *Gobius scorpioides* by Fage (1918). As yet, only young stages are recorded from southwest Iceland and the Faeroes; mature individuals no doubt remain to be discovered by systematic dredging in these waters. *Lebetus* does not appear to extend from the Belt Sea into the Baltic, and is also unknown from the southern North Sea and the eastern Channel. In the British

fauna, this goby was first known from a single example (BMNH 88. 3.22.9-10 part) obtained in Kilbrennan Sound and erroneously believed by Günther (1888) to represent the mature male of his *Gobius jeffreysii*. Collett (1896) drew attention to this mistake, and in 1898 Holt & Byrne recorded a ripe female (as *G. scorpioides*) from Falmouth Harbour. A full list of records covering the entire area of distribution is provided in the Appendix.

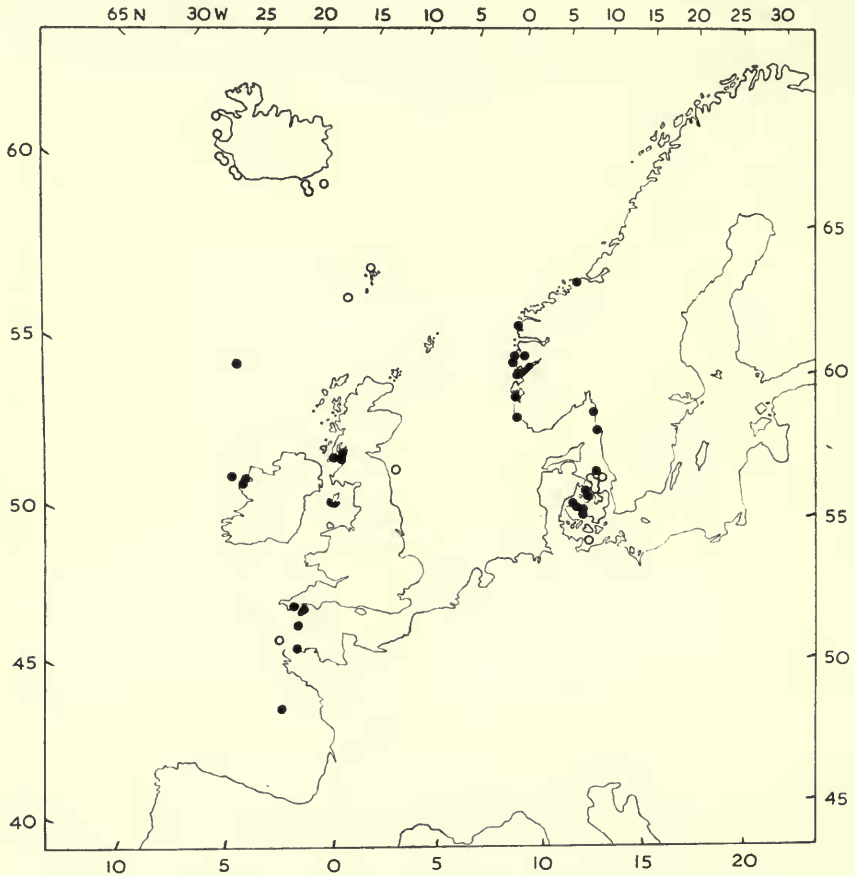


FIG. 14. Geographical distribution of *L. orca*. Locality and not number of records is indicated. Open circles denote localities from which there are only records specified as planktonic.

ECOLOGICAL DISTRIBUTION. *Lebetus orca* has been taken over a wide bathymetric range, from about 2 m. (Holt & Byrne, 1903) to 375 m. (Lilljeborg, 1884; Collett, 1902), chiefly from coarse grounds but also on mud (Patience, 1906). Le Danois (1913) regarded *Gobius scorpioides guilleti* as a characteristic inhabitant of the "maerl" deposits of calcareous algae (*Lithothamnion* spp, *Lithophyllum*) in the bays and estuaries near Roscoff although, to judge from the listed fauna and flora, these estuaries could hardly have shown a marked reduction in salinity. This type of

bottom was classified by Le Danois among the sandy and muddy sand areas of the "littoral" zone, extending down to 40 m. Together with representative animals, including *Lebetus*, a stretch of maerl is imaginatively depicted in water-colours by Le Danois (1953).

In Manx waters (Text-fig. 15), where the bottom fauna and deposits have been reviewed by Jones (1951) and Southward (1957), the species has been found on grounds ranging from muddy sand to stones and coarse gravel, always with dead shells. Calcareous algae (e.g. *Lithothamnion*) are common on stones in this area; near the shore, larger weeds may be present, and other localities where *Lebetus* has been collected are notable for the abundance of the polyzoan *Flustra*, various

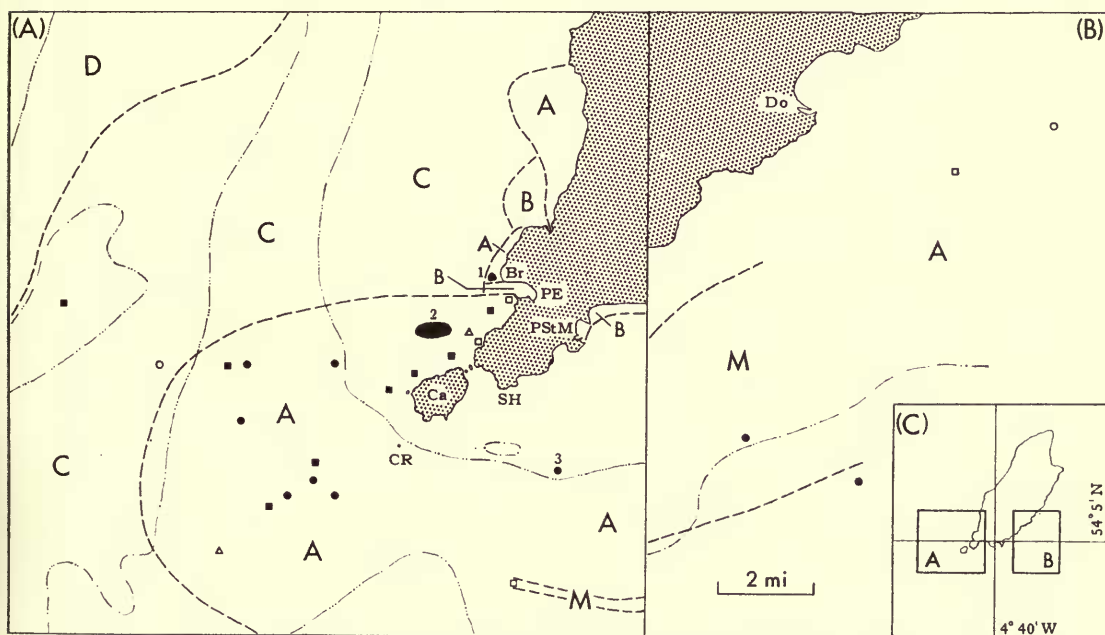


FIG. 15. Distribution of *L. orca* off the southern end of the Isle of Man. Position of areas A and B shown in c. Symbols indicate number of individuals in *orca* and *scorpioides* coloration groups respectively thus: ■, 1 *orca*; □, 1, and △, 2 *scorpioides*; ○, 1 *orca* and 1 *scorpioides*; station 1, 2 *orca* and 3 *scorpioides*; station 2, 10 and 11; station 3, 4 and 3; ●, records by Jones (1950) not examined by the author. A, stones, gravel, shell; B, fine sand; C, muddy sand; D, mud; M, *Modiolus* epifauna; - - -, approximate limits of the various deposits; - . . . -, 20 fm. (36.6 m.); - -, 30 fm. (54.9 m.); - -, 40 fm. (73.2 m.). Scale in nautical miles. Br. Bradda Head; Ca, Calf Island; CR, Chicken Rock; Do, Douglas; PE, Port Erin; PStM, Port St. Mary; SH, Spanish Head.

ophiuroids, or the lamellibranch *Modiolus modiolus* (L.). Off the Isle of Man, *Lebetus* has been found at depths from 18 to 51 m.; trawling in shallower water over the sandy bottom of Port Erin Bay and runner-dredging in deeper water on mud and finer muddy sand to the west of the island have both failed to reveal the occurrence of this species, even when the collecting gear included a bag of fine-meshed material.

Le Danois (1913) suggested that the rosy or violet coloration of *Lebetus* was a cryptic adaptation to a background of *Lithothamnion*, but the species has been obtained in the Manx area from localities where calcareous algae are missing from the dredge haul. In general, *Lebetus* is probably common on the coarser grounds around the southern end of the Isle of Man and may extend on to softer deposits where ample cover in the form of dead shells is available. Other small teleosts obtained in the same area include the rockling *Ciliata septentrionalis* (Collett), the dragonets *Callionymus maculatus* Rafinesque and *C. reticulatus* C. & V., the blennioids *Blennius ocellaris* L., *Pholis gunnellus* (L.) and *Chirolophis ascanii* Walbaum, the gobies *Buenia jeffreysii* (Günther) and *Pomatoschistus pictus* (Malm), the cottid *Acanthocottus lilljeborgi* (Collett), and the clingfish *Diplecogaster bimaculata* (Bonnaterre).

DIET. A total of 48 guts were examined, all from the Manx region. Nine of these were completely empty, and a further eight contained only a trace of food. The method adopted in assessing diet was a modification of the points system described by Hynes (1950). The number of points awarded to a stomach depended on fullness, 20 being scored by a full stomach, and this was then divided between the food items present in relation to their volume as estimated by eye. A proportionate number of additional points was allotted to food in the remainder of the gut. Half points were awarded to items occurring in very small quantities; in practice this convention enables the more insignificant items to be considered with the rest and does not result in any obvious artificial exaggeration of the importance of these constituents. Results are shown in Table IX.

Rather more than half of the gut contents was made up of crustacea. Three species of decapods together comprised the most important part of this; amphipods, chiefly Gammaridea, formed another major component but only *Amphilocheus manudens* Bate was identified among this group. None of the ostracods or harpacticoid copepods were named although these comprised an appreciable fraction of the diet. Polychaetes and lamellibranchs were the other notable food items. The vast majority of polychaete material consisted of the polynoid *Harmathoe*, which was by far the most abundant animal of any group identified in the food. About half the lamellibranch remains were unidentifiable; in the rest, the occurrence of an intact example of *Musculus marmoratus* (Forbes), 2.5 mm. long, in a fish of only 25 mm. may be noted. These findings suggest that *Lebetus*, like many other gobies, is exclusively predatory, feeding on small demersal animals. The species named are all typical of the coarser grounds inhabited by *Lebetus*. The presence of a serpulid stalk and cirripede thoracic limbs in two guts indicates that rather larger animals may be attacked, probably when the goby is attracted by movement of some appendage.

ENDOPARASITES. The parasites recorded in Table X were found during removal and inspection of guts from the Manx specimens of *Lebetus*. None appears to be common. Ectoparasites were not seen on any of the fishes studied.

REPRODUCTION. (a) Reproductive organs. The male genitalia of *Lebetus* (Text-fig. 16) display several peculiar features. The mature testes are relatively small, oval to moderately elongate, somewhat flattened bodies lying against the roof of the abdominal cavity, up to 1.5 mm. long by 0.19–0.38 mm. wide. Each testis has about 20–30 transverse lobules, enclosed by a definite tunic and emptying into a median

TABLE IX.—*Gut Contents, Number of Points Awarded, and Percentages of Total Points Awarded to Identifiable Gut Contents for More Important Constituents*

	No. of points	% of total points awarded to identifiable gut contents
POLYCHAETA		
<i>Harmathoe</i> sp. (<i>impar</i> ?)	58	} . . . 25.3
<i>Pholoë minuta</i> (Fabr.)	7	
Phyllocid indet.	1	
Serpulid opercle and stalk	1	
CRUSTACEA total		. . . 55.4
Crustacean debris	13½	
Ostracods	21	. . . 8.1
Harpacticoid Copepods	11½	. . . 4.4
Amphipods indet.	32½	} . . . 15.0
<i>Amphilochus manudens</i> Bate	1½	
<i>Paratanais batei</i> G. O. Sars	2	
Cirripede appendage	½	
Caprellid indet.	5	
Decapod appendages	1	} . . . 21.8
Hippolytid (<i>Spirontocaris</i> ?)	39	
<i>Galathea</i> sp.	4	
<i>Pagurus bernhardus</i> (L.)	13	
PYCNOGONIDA		
<i>Ammothea</i> sp.	2	
<i>Pallene</i> sp.	1	
MOLLUSCA		
Shell fragments	1½	} . . . 12.6
Gastropods indet.	5	
Lamellibranch indet.	17	
<i>Musculus marmoratus</i> (Forbes)	3½	
<i>Chlamys</i> sp., newly settled	½	
<i>Hiatella arctica</i> (L.)	12	
ECHINODERMATA		
Ophiroid indet.	7	
SAND GRAINS	1	
UNIDENTIFIABLE MATERIAL	49½	

TABLE X.—*Endoparasites Recorded from 48 Manx Examples of Lebetus orca*

Parasite	No. of fishes infected	Site of infection
TREMATODA DIGENEA		
<i>Plagioporus</i> sp.	5	intestine (3), rectum (2)
<i>Derogenes</i> sp., unencysted metacercaria	1	stomach
CESTODA PSEUDOPHYLLIDEA		
<i>Bothriocephalus</i> larvae	2	intestine (1), rectum (1)
NEMATODA ASCAROIDEA		
Anisakid larvae	3	abdominal cavity

longitudinal sperm duct. There is no pronounced band of the so-called interstitial tissue which occurs in the testes of some other gobiids (Eggert, 1931; Vivien, 1939; Coujard, 1941). Posterior to the testes, each sperm duct pursues a long and independent course to the seminal vesicle of that side. This condition appears to be derived from one in which the testis was longer with spermatogenic lobules along the entire length of the duct, since vestigial lobules are sometimes visible on the free duct in immature fishes (Text-fig. 16D). The seminal vesicles, small in the immature male (Text-fig. 16C), increase greatly in size with maturation, the anterior tips in some cases reaching as far forward as the posterior ends of the testes. They are transparent in life, conspicuously lobulate, without specialized regions, and empty into the united sperm ducts, which also receive the secretion from a small accessory glandular mass

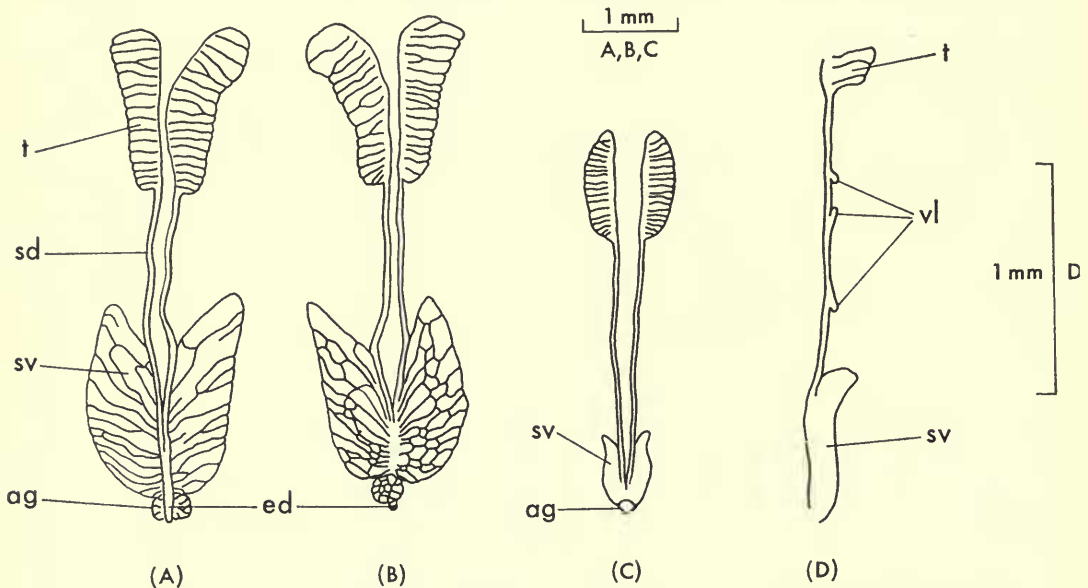


FIG. 16. Male genitalia of *L. orca*. Mature (A) dorsal view, (B) ventral view, and (C) immature, ventral view. (D) Sperm duct with vestigial lobules in immature fish. t, testis; sd, sperm duct; sv, seminal vesicle; ag, accessory gland; ed, ejaculatory duct; vl., vestigial lobules.

at the posterior ends of the seminal vesicles. The urogenital papilla of the mature male (Text-fig. 17A) terminates in a circllet of long vascularized processes. During fertilization these may perhaps embrace the tip of the egg and achieve an economy of sperm correlated with the small size of the testes. The surface of the male urogenital papilla carries a scattering of melanophores in adult specimens. In the female, the ovaries present the usual cystovarian appearance and are paired. Ripe oocytes reach a maximum diameter of probably about 0.6 mm. (Holt & Byrne, 1898; personal observation). The urogenital papilla (Text-fig. 17B) is stouter than that of the male, with the terminal villose processes shorter and broader, and, as in the immature male (Text-fig. 17C), lacks surface pigmentation.

(b) Breeding season. Holt & Byrne (1898) recorded a ripe female from Falmouth Harbour in mid-July, and, in the nearby Plymouth area, Russell (1930*b*–1940) found postlarval *Lebetus* from May to October and also in December, with August as the month of greatest abundance. Bal (1940*a, b*) obtained postlarvae in late June and July off Port Erin, Isle of Man. At Roscoff, Cantacuzene (1956) stated that the spawning season was from April to September. In the Manx material, females with swollen ovaries containing opaque yellow oocytes were present from mid-February to mid-June. Because of reduction in the amount of dredging performed, only one specimen—a male—was obtained in July and none at all in August. In early September a female was taken with ovaries showing possible traces of oocyte resorption, a process characterizing the termination of the breeding season in other gobies (Prasad, 1959 ;

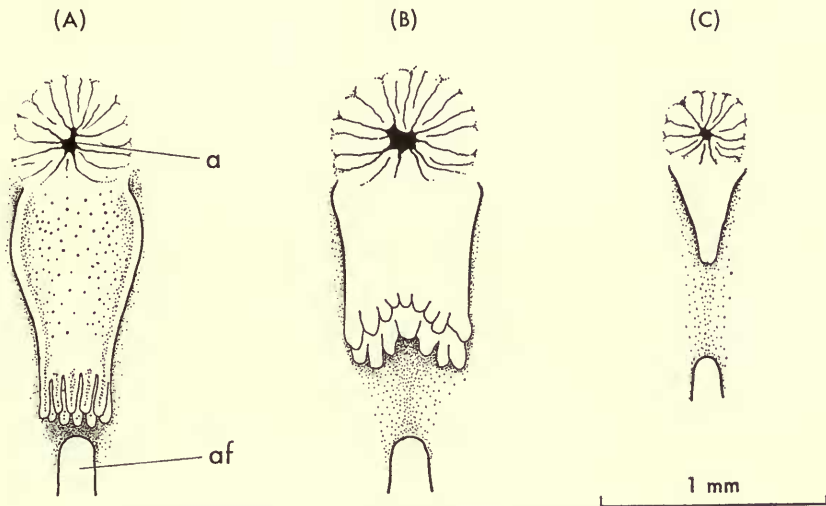


FIG. 17. Urogenital papillae of *L. orca*. (A) Mature male. (B) Mature female. (C) Immature male. a, anus; af, origin of anal fin.

Miller, 1961*a*). Fully mature males were obtained from February to July. In all probability the breeding season commences in March and may extend to August. Within such a period it seems possible that a number of broods may be produced by one female, but attempts to investigate this from size frequency distribution of oocytes have been unsuccessful because of failure to obtain a fully ripe ovary. The fertilized egg and early developmental stages of this species are unknown.

(c) Fecundity. The ovaries of four females of standard lengths 24.0, 25.0, 25.5, and 28.0 mm. contained respectively 185, 140, 270, and 194 ripening oocytes. The relatively low number of these is in accordance with the small size of this goby and are comparable to values made available by Dôtu for some small Japanese species. Thus individuals of *Paleatogobius uchidae* Takagi, 23 to 38 mm. in standard length, possessed 158–430 "ovarian eggs", *Luciogobius saikaiensis* Dôtu, 25–32 mm., 66–148, and *Eutaeniichthys gilli* Jordan & Snyder, 35–40 mm., 86–310 (Dôtu, 1955, 1957*a* ; Dôtu & Mito, 1958). In *Gobiosoma robustum* Ginsburg from Tampa Bay, Florida, Springer

& McErlean (1961) recorded 56-462 'large eggs' in females from 15-28 mm. However, larger numbers were found in *Acentrogobius masago* (Tomiyama) (14-26 mm., 264-961) and *Tridentiger undicerivus* Tomiyama (24-38 mm., 1,812-5,770), while *Gobius lidwilli* McCulloch, a species smaller than *L. orca*, contained from 154-311 eggs at 15-16 mm. (Dôtu, 1957*b*, 1958*a,b*). In the Philippine *Mistichthys luzonensis* Smith, where adult females attain lengths of 11-14.5 mm., Te Winkel (1935) counted only 20-40 mature ova per fish.

(*d*) Sexual dimorphism. This is expressed in coloration, and size of the dorsal and anal fins. There appears to be no divergence in body proportions between the sexes

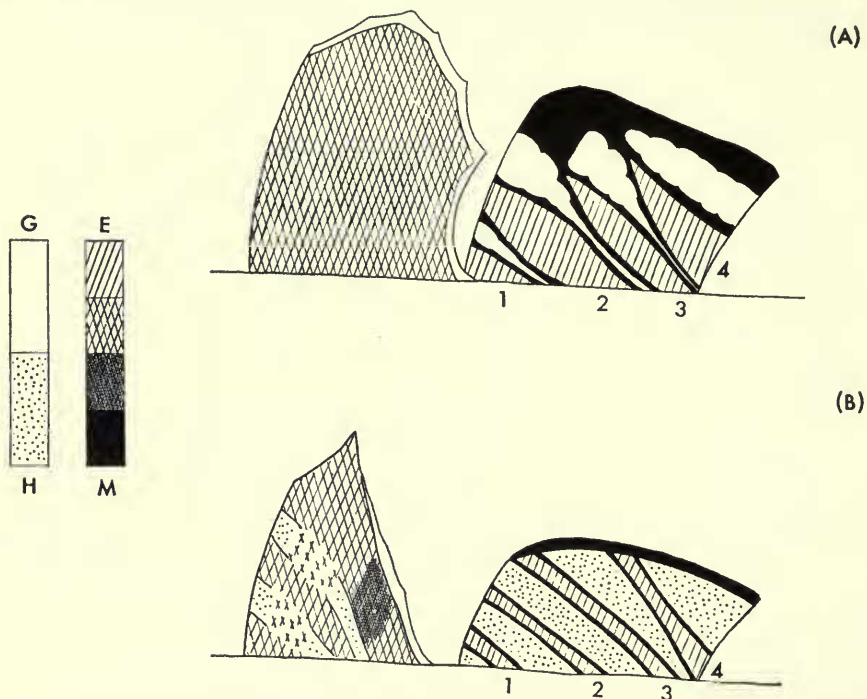


FIG. 18. Homologous areas in coloration of dorsal fins in mature male (A) and female (B) of *L. orca*. H, hyaline fin membrane; G, guanophores; E, erythrophores; M, melanophores; 1-4, comparable bands of erythrophores in second dorsal fin. Increasing admixture of melanophores with erythrophores shown by closer cross-hatching.

and both reach about the same maximum standard length. Detailed accounts of the coloration of mature individuals in each sex have been given above. Differences are most pronounced in the two dorsal fins, but pelvic, pectoral, and anal fins are all darker in the male than in the female. The components of the dorsal fin patterns are basically the same in the two sexes, and the considerable disparity between adult males and females results more from differential emphasis and spread of existing parts than from the appearance of new elements as maturity is approached. Homologous parts of the dorsal fin coloration are shown diagrammatically in Text-fig. 18. On reaching the size of maturity, dimorphism in fin size is brought about by

changes in the growth of individual rays and adjacent membrane (Text-figs. 19, 20). Growth of the second ray (II) of the first dorsal fin is about the same in the two sexes, but differences in length become more apparent in the other first and second dorsal rays investigated, especially the posterior ones of the first dorsal fin, these rays attaining a greater length in males than in females. In the male, the first dorsal membranes have considerable elasticity, and an enormous spread is achieved at full extension of the fin (Pl. I). Growth of the anal fin was not studied in detail, but a divergence in size at sexual maturity is indicated in the systematic description above.

Sexual dimorphism in teleosts has recently been reviewed by Bertin (1958). The phenomenon is of widespread occurrence among the gobies and has been investigated in Japanese species by Egami (1960). This worker lists a number of species in which the first dorsal rays are more elongate in the male, but does not mention any instances of sexual differences in coloration of the dorsal fins. In searching for dimorphism in ray length, Egami compares the lengths of only the longest ray in each fin. With the first dorsal fin of *Lebetus*, where such dimorphism in fin size is most conspicuous, this method of comparison is inapplicable since the longest ray in this fin reaches a similar length in both sexes and by itself would fail to indicate the great disparity between male and female in growth of the shorter first dorsal rays. The secondary sexual characters in *Lebetus* are probably involved in the release of certain sequences in reproductive behaviour. The enlarged dorsal fins of the male, with the contrast of bright colours disposed in an arrangement peculiar to the species, have all the characters of sign stimuli. Spawning activities in several European gobiids, where sexual dimorphism in coloration and shape of the dorsal fins may occur, are known to involve display of these fins by the male in fighting and courtship (Kinzer, 1960).

LIFE HISTORY AND GROWTH. Scale readings from Manx *Lebetus* have been interpreted in the light of unpublished data concerning scale growth in the goby *Pomatoschistus microps* (Krøyer). Results indicate that *Lebetus* may live for at least two years. In some individuals, sexual maturity may be attained at the age of about one year, while in others this stage is not reached until after the second winter of life. Insufficient material exists for studies on growth rate; the largest specimen collected, a male, was 30.0 mm. in standard length (total 37.5 mm.) and in the second autumn of life. The largest female, 29.0 + 7.0 mm., was probably nearing the end of its second year. The maximum size recorded for the genus is 39.0 mm. (Lönnerberg & Gustafson, 1935). Among the Manx collection, the smallest mature male and female individuals were 22.0 and 23.75 mm. in standard length, but Holt & Byrne (1898) obtained a ripe female of only 21.0 mm. total length. Further investigation of the life history of this species must depend on a more satisfactory means of sampling, since the scallop dredge, even when lined with fine meshed netting, appears to be highly selective of older and larger fishes.

DISCUSSION

The percomorph suborder Gobioida was defined in osteological terms by Regan (1911). Since then, the skeletons of individual species have been treated by Gregory (1933), Te Winkel (1935), Lele & Kulkarni (1938, 1939), Petit (1941), Smith (1951), and Matsubara & Iwai (1959), while Gosline (1955) has recently compared those of

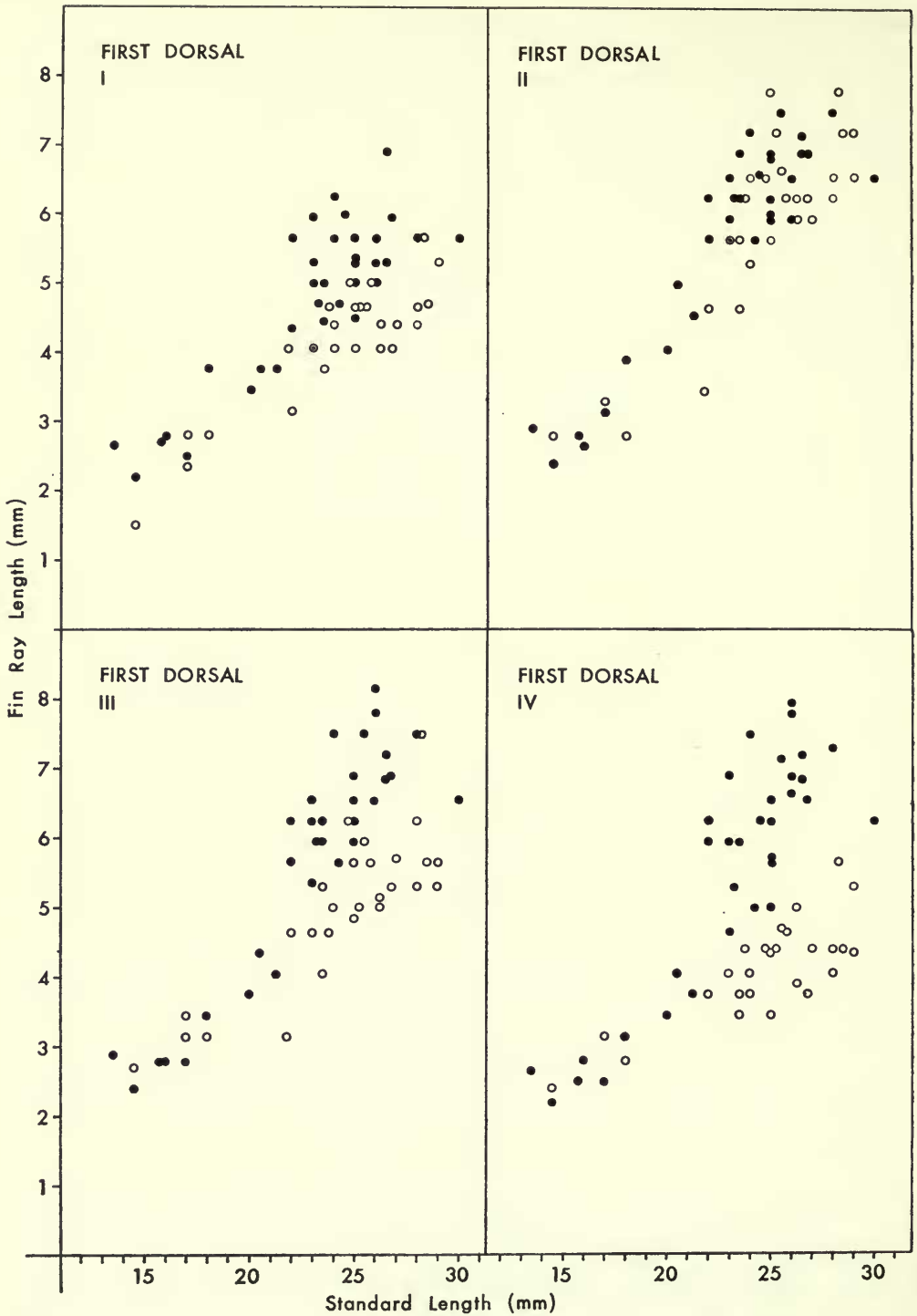


FIG. 19. Relation between standard length and lengths of first four rays of first dorsal fin (I-IV) in *L. orca*. ●, male; ○, female; ◐, coincident points.

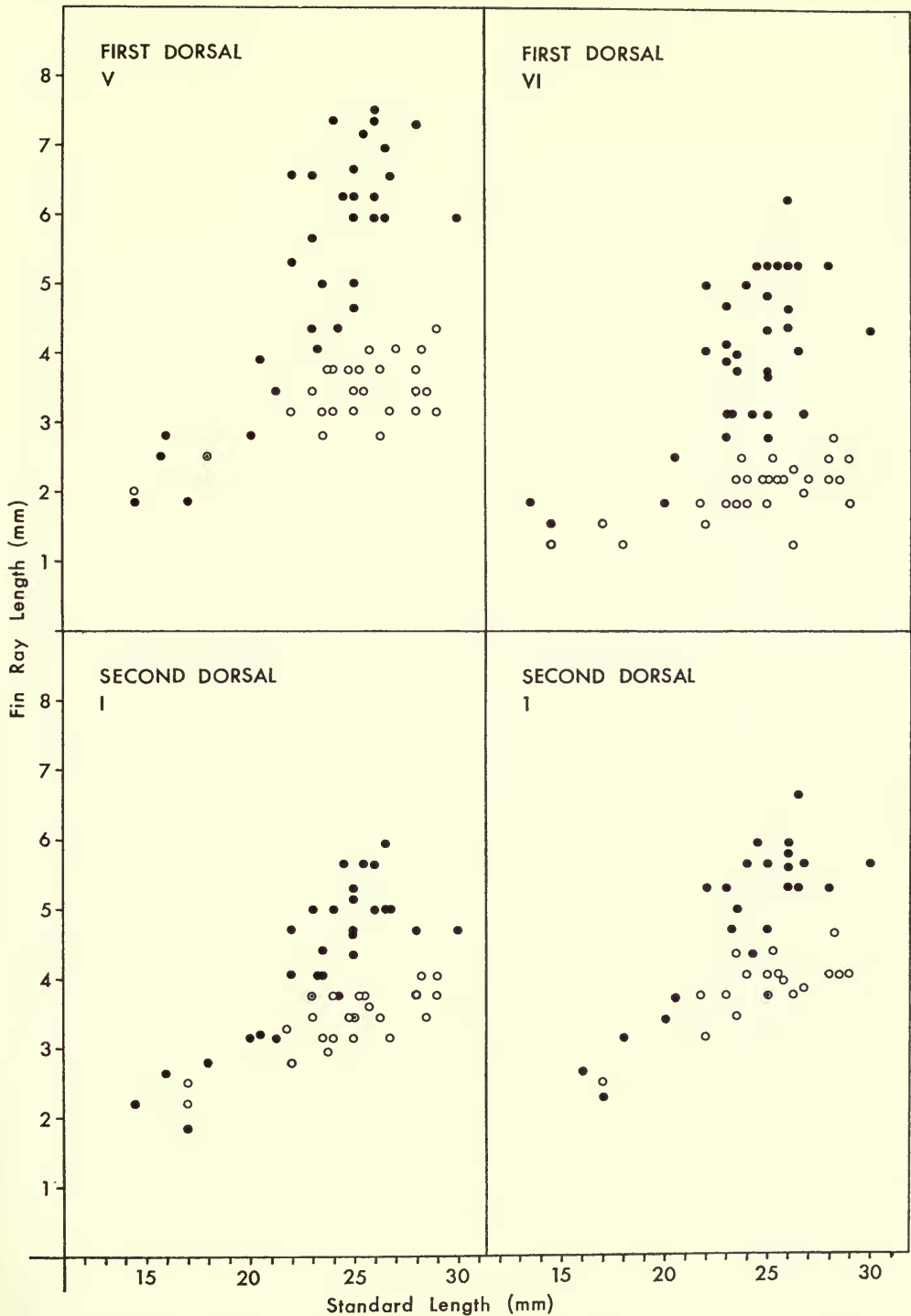


FIG. 20. Relation between standard length and length of last two rays of first dorsal fin (V, VI) and first two rays of second dorsal fin (I, 1) in *L. orca*. Symbols as in Fig. 19.

eight diverse genera of gobies. The group is characterized by several peculiarities. Among these are the large non-osseous area between the symplectic, quadrate, and preoperculum; the arrangement of the branchiostegals on the ceratohyal; the absence of the parietal bones; and the presence of a splintlike radial above and below the hypurals in the caudal skeleton. In all these features, the genus *Lebetus* appears as a typical gobioid fish, but there has been some doubt about the position of *Lebetus* among the families of this suborder. Of these about six are now recognized (Koumans, 1953; Gosline, 1955; Norman, MS.). The Rhyacichthyidae, Taenioididae, Kraemeriidae, and Microdesmidae are highly aberrant gobioids and need not be further dealt with in this discussion. The two largest and most important families are the Eleotridae and Gobiidae. Skeletal differences between these have been summarized by Regan (1911), and the diagnostic value of certain features reviewed by Gosline (1955). Nevertheless, in referring gobies to one or other of these families, it has been customary to use the external form of the pelvic fins as the chief guide in the usual absence of osteological data. According to Regan (1911) and other authors, the Eleotridae are characterized by the pelvic fins being separate, and the Gobiidae, when these fins are developed, by their union to produce a simple cup-shaped disc. However, various stages in the union or separation of the pelvic fins have been recognized among gobioid genera and the importance of this feature as a criterion of family position has recently been questioned, especially by Böhlke & Robins (1960a, b) who have found eleotrid, gobiid, and intermediate types of pelvic fins in a single genus (*Coryphopterus* Gill). In such cases as these, determination of systematic position within the suborder requires investigation of the skeleton.

When erecting the genus *Lebetus*, Winther (1877) emphasized that the anterior membrane of the pelvic disc was missing, although the two fins were joined along their entire length in the midline. At first accepting (1885) the new genus, Collett (1896) was later of the opinion that intermediate stages in reduction of the anterior membrane could be found between the fully developed condition in *Gobius* and complete loss as reported for *Lebetus*, and doubted the validity of separating the latter from *Gobius*. On the other hand, Duncker (1928) found that the two pelvic fins were completely separated in *Lebetus* but stressed the desirability for re-examination of these fins in better preserved material in order to decide whether *Lebetus* belonged to the Eleotridae or the Gobiidae. De Buen (1930b) associated *Lebetus* with two Mediterranean genera, one of which had previously been regarded as an eleotrid because of its almost completely separated pelvic fins, and placed this "*Lebetus*" group in the subfamily Gobiinae of the Gobiidae. Koumans (1931) similarly accepted *Lebetus* as a gobiid genus. In the present work, it has been confirmed that, in the least damaged examples, the pelvic fins of *Lebetus* are completely united between their origins and the distal extremity of the fifth ray of each fin, but are entirely without trace of an anterior membrane to complete the disc. To settle the question of family position with greater certainty, it became obvious that examination of the skeleton was necessary, and the results of this study reveal that *Lebetus* has the characters of a typical member of the Gobiidae. These include a T-shaped head to the palatine, loss of the mesopterygoid from the palatopterygoid arch, and absence of a hypercoracoid in the pectoral girdle, where the laminar radials are inserted on the cleithrum

and the lowest also related to the hypocoracoid. In the possession of a spatulate glossohyal, five branchiostegous rays, a reduced metapterygoid, and loss of the opisthotic, *Lebetus* also reaches a higher level of specialization than that described among the eleotrids (Regan, 1911; Takagi, 1950; Gosline, 1955).

Within the Gobiidae, the affinities of *Lebetus* undoubtedly lie with the subfamily Gobiinae, since the genus exhibits none of the more extreme modifications of the Sicydinae, Periophthalminae, Apocrypteinae, Tridentigerinae, Gobiodontinae, or Benthophilinae (Koumans, 1953; Norman, MS.). In the absence of an anterior membrane to the pelvic disc, *Lebetus* resembles a number of small Indo-Pacific genera i.e. *Herreogobius* Koumans, *Quisquilius* Jordan & Everman, *Fusigobius* Whitley, *Amblyogobius* Bleeker, and *Zonogobius* Bleeker (Koumans, 1953; Gosline, 1959). With head and anterior part of body naked, elongate rays in the first dorsal fin, 22-30 scales in lateral series, and radial formula of D_2 1/8-9, A 1/7-8 (Koumans, 1953), *Zonogobius* appears to be closest of these to *Lebetus*. Differences comprise the larger gill openings, and more laterally compressed head in *Zonogobius*. However, it is impossible to trace relationships between European and exotic genera, when the arrangement of the lateral line system in so many of the latter, including *Zonogobius*, remains to be adequately described and figured. As shown in the normal illustration of *Zonogobius corallinus* sp. nov. (Mozambique) by Smith (1959, Fig. 29), the distribution of sensory papillae on cheek and postorbital regions differs from that of *Lebetus* in the complete longitudinal rows and more numerous papillae. Koumans (1931) associated *Lebetus* with the genus *Coryphopterus* Gill; as defined by Koumans, the latter included European *Pomatoschistus* species together with the genotype, *C. glaucofraenum* Gill, from the tropical Western Atlantic. In a revision of *Coryphopterus* sensu stricto, Böhlke & Robins (1960b) provide details of the cephalic lateral line system and other characters which do not point to any close affinity with *Lebetus*, in spite of the fact that two of their new Western Atlantic species (*C. alloides* and *C. dicrus*) are without the anterior pelvic membrane.

In the European fauna there are two Mediterranean genera of gobies lacking anterior membranes to the pelvic fins. These are *Odondebuena* and *Cabotia*, both introduced by De Buen (1930b). Since *Cabotia* is preoccupied among the Lepidoptera, De Buen (15th June, 1940) suggested *Fagea* as a replacement but was preceded in this by Whitley (May, 1940) who introduced *Cabotichthys*. The genus *Odondebuena* contains two species which were originally (1907) placed among the Eleotridae as *Eleotris balearicus* Pellegrin & Fage and *E. pruvoti* Fage. *Odondebuena* is characterized by pelvic fins united only at their bases, naked nape and throat, unusual gill rakers (Fage, 1907, figs. 3 and 9), modified scales at the origin of the caudal fin, and meristic characters of D_2 1/9-11, A 1/8-10, and Sc.1.1.24-32. Both species of *Odondebuena* show sexual dimorphism in length of first dorsal fin rays (Fage, 1918; De Buen, 1930b). The second of these Mediterranean genera, *Cabotichthys*, has the pelvics joined together for about half their length, nape and throat fully scaled, scales of the caudal peduncle not modified, and fin ray and scale counts of D_2 1/14, A 1/13, and Sc. 1.1.50. The genus is founded on one species, *C. schmidti* (De Buen) known only from the single type specimen (De Buen, 1930b). De Buen (1931) included *Odondebuena*, *Cabotichthys* and *Lebetus* in his "*Lebetus*" group of genera, the principal

character of which is the absence of the anterior pelvic membrane. Similarities in habitat also link these fishes, all three being obtained on coarse grounds where calcareous algae are noticeable constituents of the bottom deposits, and none exceed 50 mm. in length.

On the face of the diagnoses given above, *Lebetus* would appear to be fairly closely related to *Odondebuenia* except for the occurrence in the latter of modified caudal scales and gill rakers, and the greater separation of the pelvic fins, while *Cabotichthys* stands quite distant from both in several respects. The lateral line system in *Odondebuenia* and *Cabotichthys* has fortunately been investigated by De Buen (1930b, 1940) and that of *Lebetus* is described above. Comparison of these accounts for the three genera reveals the heterogenous nature of their grouping. The patterns of sensory papillae and extent of the cephalic canals in *Cabotichthys* point to an intimate connection with the genus *Gobius*, as defined by De Buen (1930a, 1931), and, apart from the reputed form of the pelvics, other characters of this fish do not warrant any generic separation from *Gobius*. My own experience with dredged and trawled examples of *Lebetus* and other gobies is that the pelvic membranes are very susceptible to damage, and the pelvics of *Cabotichthys*, as figured by De Buen (1930b, fig. 7) are reminiscent of such a condition. It may well prove that *C. schmidti* is no more than a damaged specimen of a *Gobius* species.

The state of the pelvics in the *Odondebuenia* species seems well established from a number of specimens. In the arrangement of sensory papillae, this genus differs markedly from *Lebetus* in the greater number of papillae, and their distribution in well marked transverse and longitudinal rows on the cheek approaches that in *Gobius*, which *Odondebuenia* also resembles in the possession of a similar cephalic canal system. The morphological attributes common to both *Odondebuenia* and *Lebetus* are not of a very highly specialized nature and do not outweigh the considerable disparity in patterns of sensory papillae. Modification of scales at the base of the caudal fin involves pronounced elongation of all the ctenii in *O. pruvoti* (Fage, 1907, fig. 7) or merely the lateral ctenii in *O. balearica* (Fage, 1907, fig. 11; De Buen, 1930b, fig. 2). Although not seen in *Lebetus*, it is of interest to note the occurrence of this peculiarity in the new gobioid genus *Varicus*, recently described from the West Indies by Robins & Böhlke (1961) and also with separated pelvic fins. These authors commented on the existence of comparable scales in the Californian eleotrid *Chriolepis* Gilbert and the gobiid *Garmannia* Jordan, which is represented on both sides of Central America and in the Caribbean. It is not proposed at this point to deal further with the relationships of *Odondebuenia*, except to call attention to the need for an osteological investigation of this genus.

Loss of the anterior membrane from the pelvic disc has probably occurred on a number of different evolutionary lines among the Gobiidae and, as in the case of *Odondebuenia* and *Lebetus*, need not be a sure indication of close phyletic association. In geographical distribution *Lebetus* appears to be confined to the eastern Atlantic boreal region and may well have evolved there. It is in this area, therefore, that the closest relatives of the genus may be sought. Eight other gobioid genera are recorded from the eastern North Atlantic (De Buen, 1931) and all of these have a pelvic disc complete with anterior membrane. The two pelagic forms *Aphyia* Risso and *Crystal-*

logobius Gill may be excluded from consideration on the grounds of extreme specialization. Among the demersal gobies, the genera *Deltentosteus* Gill, *Pomatoschistus* Gill, *Chaparrudo* De Buen, and *Gobius* L. exhibit various features of anatomy and lateral line organization (see De Buen, 1930a, 1931) which do not suggest any near relationship with *Lebetus*. The remaining genera, *Lesueurigobius* Whitley and *Buenia* Iljin, deserve more attention. The first of these, represented by *Lesueurigobius friesii friesii* (Collett), has a number of characters in common with *Lebetus*. Thus both genera are entirely without cephalic canals and in disposition of sensory papillae show a posterior extension of row *a* behind the eye, papillae in the oculoscapular furrow (row *u*), interorbital papillae, a high posterior termination for row *i*, and reduction of rows *m*, *n*, and *o* (Sanzo, 1911, pl. 9, figs. 4, 5, as *Gobius macrolepis*; De Buen, 1923, figs. 21, 22). However, the great abundance of papillae in *Lesueurigobius* contrasts with their relative scarcity in *Lebetus*, where several rows (*g*, *x*, *z*, *c*², *b*, *d*) found in *Lesueurigobius* are little if at all developed, and others (*i*, *e*, *ot*, *c-cp*) interrupted. Except for reduction in rows *m*, *n*, and *o*, the resemblances listed may be accounted for by independent action of a similar evolutionary process in the past history of each genus. This was the replacement of existing cephalic canals by rows of sensory papillae. Considerable anatomical differences in size, habit, squamation, radial formulae, and coloration (Holt & Byrne, 1903; Duncker, 1928) would also suggest similarities are due to convergence, and that any affinity is relatively distant. No closer relationship can be demonstrated with *Lesueurigobius sanzoi* (De Buen) or *L. lesueuri* (Risso) from the Mediterranean (De Buen, 1923).

The only genus now remaining is *Buenia*, the Atlantic species of which is *B. jeffreysii* (Günther), and it is with this form that *Lebetus* appears at present to be most closely connected. Lacking scales on the head and predorsal regions, and with meristic characters of D₂ I/8-9, A I/7-8, and Sc. 1.1.25-30 (Duncker, 1928; personal observation), *B. jeffreysii* displays a resemblance to *Lebetus* which is also evident in the arrangement of the lateral line system (Text-fig. 21). On the cheek absence of transverse rows of papillae, and the short row of large papillae with an intermediate papilla between this and row *a*, recall the conditions in *Lebetus*. The lateral preorbital rows *c*¹ and *c*² are identical in both genera. On the dorsum of the head there is a correspondence in the reduced number and the arrangement of the papillae. *Lebetus* differs from *B. jeffreysii* in the disappearance of cephalic canals and their replacement by papillae of rows *a*¹, *u*¹, *i*¹, and the anterior part of *n*, together with a certain "condensation" of other rows (*d*¹, preoperculo-mandibular, opercular, and other series) and loss of rows *d* and *b*. The pattern of sensory papillae in *Lebetus* is obviously more specialized than that in *Buenia*, but the features present in both denote a greater affinity between these two gobies than is exhibited between *Lebetus* and other genera. In the persistence of cephalic canals and various rows of papillae, *Buenia* displays more ostensibly primitive characters than *Lebetus*. The former in addition retains the anterior pelvic membrane, is not so small as *Lebetus*, and does not show pronounced sexual dimorphism, although this does occur in growth of the first dorsal fin rays and probably in coloration of this fin. In the male genitalia, the testes are long and there is no free sperm duct. *B. jeffreysii* may accordingly show greater resemblance to the common stock from which the two are derived. The Mediterranean

species *B. reticulatus* (C. & V.) (= *B. affinis* (Kolombatovic)) is more removed from *Lebetus* in having a greater number of papillae especially in rows *b* and *d*, and a somewhat higher scale count (more than 33), than *B. jeffreysii* (Sanzo, 1911, pl. 9, figs. 9, 10; De Buen, 1930a). In Manx waters *B. jeffreysii* has an offshore distribution

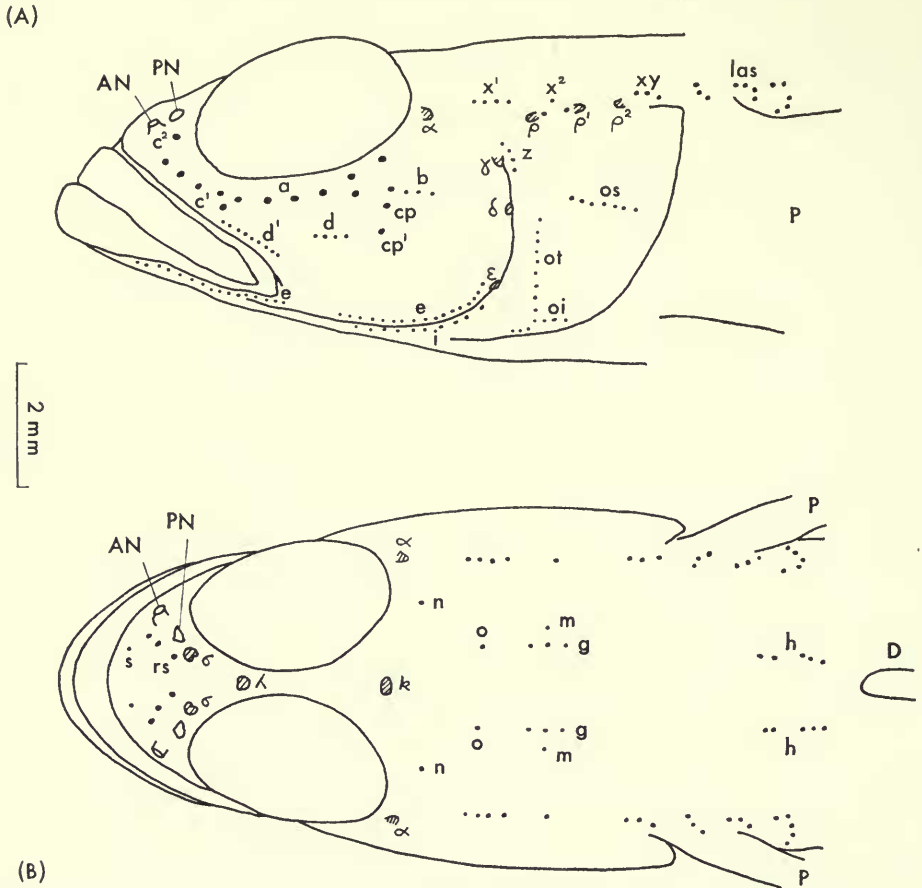


FIG. 21. Sensory papillae and orifices of cephalic canals in *Buena jeffreysii*, male, 31 mm standard length. (A) Lateral, (B) dorsal views of head. Abbreviations as in Fig. 7. Orifices of canals cross-hatched, with greek lettering as in Sanzo (1911).

like *Lebetus* and has even been taken from the same localities (see also Le Danois, 1910), but differences in precise habitat are perhaps reflected in the different body form and coloration (Holt & Byrne, 1903, fig. 4).

Some of the characters of *Lebetus* may be interpreted as adaptations to a mode of life involving intimate association with dead shells, nodules of calcareous algae, and stones. The small size of the fish is obviously related to this type of habitat, and the normal coloration may have cryptic value against a background of *Lithothamnion*. Te Winkel (1935) has discussed those anatomical features of the gobiid *Mistichthys*

luzonensis which may be correlated with the extremely small size of this species at maturity (standard length 10.0–11.0 mm.). Although *Lebetus* is diminutive, it is appreciably larger than *Mistichthys* and the only obvious comparable modification in this genus is the reduced size of the testis, to which may be related the form of the urogenital papilla as considered above. A more detailed examination of the viscera than was attempted in the present study would be needed to investigate this question. Reduction in number of sensory papillae has already been mentioned, and may be linked with small body size (Barlow, 1961b). The significance of loss of the cephalic canals is unknown; these are also lacking in *Lesueurigobius*, which attains 100 mm. in *L. friesii*, but are present in smaller forms such as *Odondebuena*, *Buenia*, etc. Another feature of probable adaptive importance is the absence of the anterior pelvic membrane, since this is also missing in *Odondebuena* which appears to have a similar habitat and which in addition exhibits almost complete separation of the pelvic fins. While the exact affinities of *Odondebuena* await investigation, it seems likely that in view of the resemblances in arrangement of sensory papillae between this genus and *Gobius* the condition of the pelvics is derived from an original gobiid disc structure in response to environmental demands, and is not primitive as in the Eleotrids. The advantages conferred by the alteration of the pelvic disc in *Lebetus* and *Odondebuena* are not obvious. The loss of the anterior membrane seems to have occurred independently in the evolution of the two genera as the exploitation of similar ecological niches proceeded in two areas from different stocks.

It must be stressed that the above phylogenetic conclusions may at present be regarded as tentative. Not only does the position of *Odondebuena* remain doubtful, but the alignment of *Lebetus* with *Buenia* may well be affected by future work on the lateral line system of exotic gobies and faunistic exploration in little known areas, which together could disclose closer resemblances and intermediate forms between these and *Lebetus*.

SUMMARY

The teleostean genus *Lebetus* Winther 1877 (Percomorphi-Gobioidea) has been studied from new Irish Sea material dredged off the south of the Isle of Man, and from other examples, including types, in the collections of various British and Scandinavian museums. A redefinition of the genus includes the disposition of sensory papillae; there is a reduction in number of the latter, and cephalic canals and an anterior membrane to the united pelvic fins are lacking. Two species were previously recognized: *orca* Collett 1874 and *scorpioides* Collett 1874. Among the various criteria—coloration, meristic characters, body proportions—used in the past to distinguish these two species, it was found that only in coloration and development of the dorsal fins could the present *Lebetus* material be divided into two groups, termed *orca* and *scorpioides*. The former consisted entirely of males, nearly all maturing or mature, the latter of females and immature males. The conclusion is reached that there is only one valid species, by page priority *Lebetus orca*. A detailed account of the external anatomy and osteology of this species is provided.

In distribution *L. orca* is restricted to the European Atlantic boreal region, and a full list of records is provided in an appendix. The species is known chiefly from

coarse grounds, and has a wide bathymetric range from about 2 to 375 m. Investigation of gut contents, using a points system of assessment, shows that *L. orca* is exclusively predatory, feeding on small demersal animals which largely comprise crustacea and polychaetes. A number of endoparasites are listed. The male reproductive organs are peculiar in the relatively small size of the testis and the long free sperm duct; "seminal vesicles" are present. Sexual differences exist in the form of the urogenital papilla, which in mature males has an unusual terminal circlet of vascularized papillae. In Manx waters, the breeding season probably commences in March and may extend to August. 140 to 270 ripening oocytes have been counted in mature females. Sexual dimorphism is found in coloration, and size of dorsal and anal fins. Examination of scales indicates that duration of life may be at least two years, with sexual maturation at one or two years. Maximum total length recorded is 39.0 mm. Investigation of life history and growth in the Manx specimens was complicated by the high selectivity of the sampling gear employed.

In a discussion of the systematic position of *Lebetus*, it is shown that the skeleton is typically gobiid, and the arrangement of sensory papillae together with other features suggest that the nearest relative of this genus among the European gobies is *Buenia jeffreysii* (Günther). Previous grouping of *Lebetus* with two Mediterranean genera lacking an anterior pelvic membrane (*Odondebuenia* De Buen and *Cabotichthys* Whitley) is criticized. The validity of *Cabotichthys* is doubted, and the suggestion is made that loss of the anterior membrane in *Lebetus* and *Odondebuenia* occurred independently during their evolution and occupation of a similar habitat in different areas.

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APPENDIX

Distribution of *Lebetus orca*

A list of published and unpublished records known to the author is given below. A complete sequence of information is as follows : locality, number of specimens, sex, museum number, standard length + caudal fin length or total length in millimetres (mm.), depth of water in metres (m.), nature of ground, date of capture, and authority in the case of published records. When a number of records from the same locality or area are given in the one publication, these are separated by semicolons and the authority placed at the end. Abbreviations employed are : c., coarse ground ; cl., clay ; d., damaged ; gr., gravel ; h., hard ground ; *Lith.*, *Lithothamnion* ; m., mud ; midw., midwater ; *Mod.*, *Modiolus* ; n.d., no date ; s., sand ; sh., shells ; st., stones ; surf., surface ; t.l., total length ; w., weed.

ICELAND : Off S. and W. coasts, Eystra Horn to Breiðfjörður, "pelagic fry . . . rather rarely" (Tåning, 1940 ; Saemundsson, 1949).

FAEROES : Off N. coast, and Faero Bank, postlarvae (Tåning, 1940).

ROCKALL : On and near Rockall Bank, 1908 (Tåning, 1940).

NORWAY

Hemnefjord (Trondelag) : one ♂ (ZMO J4001), 23.0 + d.mm., July 1882 (Collett, 1885).

Søndfjord (Sogn og Fjordane) : Batalden, one ?♂ (ZMO J4000), t.l. 22.0 mm., 375 m., summer 1875 (Lilljeborg, 1884 ; Collett, 1902).

Fedjefjord (Hordaland) : Herdla, two ♂♂ (ZMB 4174, 4175), 24.25 + d. and 26.0 + 7.25 mm., n.d. and 20 Aug. 1918.

Sørfjord (Hordaland) : Between Bruvik and Stamnes, one ♂ (ZMB 5294), 24.0 + 6.25 mm., 20-30 m., gr.s., 11 July 1953.

Hordaland : Bergen area, one, t.l. 29.0 mm. (Lilljeborg, 1884 ; Collett, 1902). Solsvig, one ♂ (ZMB 771), t.l. 31.0 mm., 56 m., sh.s., July 1899 (Collett, 1902). Herløvaer, one ♀ (ZMB 536), t.l. 28.0 mm., 37 m., sh.s., July 1898 (Grieg, 1899 ; Collett, 1902).

Hardangerfjord : Espevaer, one ♂ (ZMO J3999), 26.0 + 6.0 mm., 145-180 m., c.s., July 1873 ; Lyngholmen, one ♀ (ZMO J4021), 30.0 + 7.0 mm., 110 m., August 1873 (Collett, 1874, 1875*a*). Nordre Bratholmen (Hjelvefjord), one ♂, 23.5 + 7.0 mm., 50-100 m., sh.s., 30 Mar. 1903 ; Bognestrømmen, one ♂ (ZMB 1966), 26.5 + 6.0 mm., 20-40 m., gr.s., 26 Apr. 1903 ; Guldholmen (Solsvik), one ♀ (ZMB 2009), 28.0 + 6.0 mm., 30-60 m., 25 Sept., 1903 ; Djupevik, one ♂ (ZMB 1893), 23.0 + 6.0 mm., 40-80 m., sh.gr.s., and one ?♀, 27.5 + 5.0 mm., 20-60 m., sh.gr., 2 July 1909 ; Straumastein (Jondal), one ♂ (ZMB 1887), 18.5 + 4.0 mm., 100-200 m., sh.s., 15 June 1909 (Greig, 1913).

Stavangerfjord : Hvitingsø, one ♀ (ZMO J4020), t.l. 28.0 mm., 37 m., July 1872 (Collett, 1874, 1875*a*).

Rogaland : Egersund, one ♂ (ZMO J4023), 24.0 + 6.0 mm., 55 m., s., 12 Aug. 1880 (Collett, 1885).

SWEDEN

Kosterfjord (Göteborg) : May 1895 (Duncker, 1928). Sneholm, one, t.l. 35 mm., 100 m., st.; Säcken, one, t.l. 39 mm., 80 m., coldwater coral reef (Lönnberg & Gustafson, 1935).

Gullmarfjord (Göteborg och Bohus) : August 1926 (Duncker, 1928). Flatholmen, two, 15-20 m., red algae (Lönnberg & Gustafson, 1935).

DENMARK

Kattegat : Anholt Light NW. by $W\frac{1}{2}N.$, two, 45 m., 18 Apr. 1902 (Otterstrøm, 1912). Anholt, one, t. l. 16 mm., May 1902 (Petersen, 1919). SW. Anholt Harbour ($56^{\circ} 37' N.$, $11^{\circ} 22' E.$), fifty-four, upper and midw. in 18 m., 14 Apr. 1925 ; S. Anholt ($56^{\circ} 30.5' N.$, $11^{\circ} 35' E.$), sixteen, upper and midw. in 31 m., 14 Apr. 1925 ; E. Store Middelgrund ($56^{\circ} 33.5' N.$, $12^{\circ} 13' E.$), one, midw. in 48 m., 8 Apr. 1925 ; $56^{\circ} 15' N.$, $11^{\circ} 53' E.$, nine, 13.0-17.0 mm., upper and midw. in 25-26 m., m.s., 20/21 Apr. 1925 (Johansen, 1925). Hesselø, about twenty young, August 1918 (Petersen, 1919). Yderflakket (between Sjaellands Odde and Hjelmen), one ♂ (ZMC 91), 14.4 + 4.0 mm., 11 m., st.gr.w., 18 Aug. 1876 (Winther, 1877). Sjaellands Odde, one ♂ (ZMO 89), 14.5 + 4.5 mm., 22 May 1913.

Great Belt : "fairly often single or a few young specimens", c. 18-20 m. (Petersen, 1919). Tørræsø (N. of Fünen), June 1912 ; Oddens Havn, May 1913 (Duncker, 1928). SE. Romsø ($55^{\circ} 30' N.$, $10^{\circ} 52' E.$), five, midw. in 30 m., 16 Apr. 1925 (Johansen, 1925). Kerteminde, one, t.l. 15.0 mm., 4 m., 19 May 1904 ; Nyborg, "small young", Aug. 1917 ; E. Palegrund, two, t. l. : 3.5 and 4.5 mm., 6 Aug. 1917 ; E. Vresen's buoy, one, t. l. : 5.5 mm., 24 m., 19 Sept. 1917 (Petersen, 1919).

Fehmern Belt : SE. Staberhuk ($54^{\circ} 22' N.$, $11^{\circ} 23' E.$), one, midw. in 23 m., 17 Apr. 1925 (Johansen, 1925).

BRITISH ISLES

Northumberland : Off Alnmouth ($55^{\circ} 24' N.$, $1^{\circ} 31.5' W.$), larvae, 8 Sept. 1925 (Ehrenbaum *et al.* (1929) attribute this record to Schnakenbeck (1928) but a search through this paper has failed to reveal it).

Clyde Sea Area : Kilbrennan Sound, one ♂ (BMNH 90.10.20.9-10), t.l. 37.5 mm., 22 Mar. 1888 (Günther (1888) as ♂ *Gobius jeffreysii* ; Collett, 1896). Between Scalpsie Bay and Cock of Arran ($55^{\circ} 44' N.$, $5^{\circ} 11' N.$), one ♂, 26.0 + 8.0 mm., 135-160 m., m. ; Largs Channel ($55^{\circ} 45' N.$, $4^{\circ} 54' W.$), one ♀, 29.0 + 7.0 mm., 35 m., h. ; Firth of Clyde ($55^{\circ} 41' N.$, $5^{\circ} W.$), one ♂, 27.0 + 7.0 mm., 93 m., m. (Patience, 1906). E. Cumbrae, off Cock of Arran, in over 146 m. (Elmhirst, 1926).

Ireland : Inislyre Harbour, Clare Island (Mayo), one, 9 m., sh.st., May 1909 (Farran, 1912). Ballynakill Harbour (Galway), several, including two ♂♂, 12.0 + d. and 16.0 + 4.0 mm., and two ♀♀, 10.5 + d. and 17.0 + 5.0 mm. (BMNH 1903.4.14.4-7), 2-5.5 m., sh.st. *Lith.* ; 30 mi WNW. Cleggan Head (Galway), one, ?♀, 135 m. (Holt & Byrne, 1903).

Irish Sea : Up to 2 mi off Bradda Head (Isle of Man), eight, t.l. 3.5-8.0 mm., at 4.5-7.2 m., 18 May-19 July 1939 (Bal, 1940*a*). 2½ mi WSW. Chicken Rock (Isle of Man), one, 37 m., sh., 29 May 1947 ; 1¾ mi SW. by W. Chicken, one, 37 m., sh.gr.m., 5 Aug. 1947 ; 2 mi. WSW. Chicken,

one, 37 m., sh., 11 Sept. 1947; $3\frac{1}{2}$ mi WNW. Chicken, four, 49 m., sh.s., 6 Aug. 1948; 3 mi SW. by S. Chicken, two, 42 m., sh., 21 Sept. 1948; 3 mi W. 5° N. Chicken, one, 51 m., sh.st., 21 Sept. 1948; $4\frac{1}{2}$ mi ESE. by 5° E. Langness (Isle of Man), one, 35 m., st.*Mod.*, 24 Sept. 1948; $6\frac{3}{4}$ mi ESE. by 5° E. Langness, one, 42 m., sh.st.gr., 25 Sept. 1948; 3 mi ESE. Douglas Head (Isle of Man), three, including ♀ 18.0 + 5.75 mm., 29 m., sh.*Lith.*, 22 Nov. 1948; $1\frac{1}{2}$ mi WSW. Chicken, one ♂ (PEM), 26.5 + 6.5 mm., 44 m., m.s., 10 May 1949; 4 mi SW. Chicken, one ♀ (PEM), 28.0 + 6.2 mm., 40 m., sh.st. (Jones, 1949, 1950, 1951). Five mi E. Douglas Head, one ♂, 23.5 + 6.5 mm. and one ♀, 23.5 + 5.5 mm., 33 m., sh.*Lith.*, 22 Sept. 1948; $\frac{1}{4}$ mi NE. Calf Stack (Isle of Man), one ♂, 26.0 + 6.8 mm., sh.st., 7 May 1957; $\frac{3}{4}$ -1 mi N. Calf Island, eleven ♂♂, 20.5 + 5.5 to 26.75 + 7.25 mm., and nine ♀♀, 23.75 + 6.25 to 28.0 + 6.5 mm., 18-35 m., sh.st.*Lith.*, 25 Mar. 1958 to 31 Oct. 1960; $1\frac{1}{4}$ mi N. by E. Calf, one ♀, 25.0 + 6.0 mm., sh.m., 4 Apr. 1960; 4 mi S. Spanish Head (Isle of Man), one ♀, 28.0 + 7.0 mm., 53 m., *Mod.*, 11 Mar. 1958; Off Aldrick Bay (Isle of Man), two ♀♀, 23.5 + 5.5 and 25.75 + 6.5 mm., 20 Oct. 1958 and 5 Nov 1959; $\frac{1}{4}$ mi W. Bradda Head, two ♂♂, 23.25 + 6.5 and 30.0 + 7.5 mm., one ♀ 23.0 + 6.0 mm., 25 Nov. 1958, and two ♀♀, 17.0 + 4.75 and 24.5 + 6.5 mm., 14 Apr. 1959, 27 m., sh.st.m.s.w.; $2\frac{1}{2}$ mi S. Perwick Bay (Isle of Man), four ♂♂ (including BMNH 1961.10.17.1, 3), 23.0 + 6.2 to 28.0 + 6.3 mm., one ♀ (BMNH 1961.10.17.2), 29.0 + 7.0 mm., 10 Feb. 1959, and two ♂♂, 17.0 + 4.5 and 20.0 + 5.0 mm., 16 Nov. 1959, 35 m., sh.st.gr.*Lith.*; $\frac{1}{4}$ mi W. Port Erin Breakwater (Isle of Man), one ♂, 15.75 + 4.4 mm., 9-27 m., st.gr.w., 28 Sept. 1959; W. Calf Sound, one ♂, 23.0 + 5.75 mm., sh.st.m.s., 29 Sept. 1959; Aldrick Bay, one ♀, 14.5 + 4.0 mm., 18 m., sh.gr., 2 Oct. 1959; $2\frac{3}{4}$ mi W. Calf Sound, one ♀, 26.75 + 6.75 mm., sh.st.gr., 16 Oct. 1959; $\frac{1}{2}$ mi N. Aldrick Rock, one ♂, 24.25 + 5.75 mm., sh.m.s.w., 9 Dec. 1959; 4 mi SW. Chicken, one ♀ (BMNH 1961.10.17.4), 28.25 + d. mm., 51-58 m., sh.gr., 10 Feb. 1960; $6\frac{1}{2}$ mi W. Sound, one ♂, 22.0 + 6.0 mm., and two ♀♀, 25.25 + d. and d. mm., 49-64 m., sh.gr.m.s., 3 May 1960; 5 mi W. Sound, one ♂, 24.5 + 6.75 mm., 55 m., 8/14 June 1960; $9\frac{1}{2}$ mi W. Port Erin, one ♂, 23.5 + 6.0 mm., 60-65 m., sh.m.s., 8 July 1960; $1\frac{1}{4}$ mi N. Chicken, one ♂, 26.0 + 6.0 mm., 42 m., sh. and abundant *Flustra*, 3 Feb. 1961; 3 mi WSW. Chicken, one ♂ (BMNH 1961.10.17.5), 25.0 + 6.5 mm., 42 m., sh., 10 May 1961; also from Manx area, exact localities unrecorded, three ♂♂, 16.0 + 4.5 to 26.5 + 7.0 mm., and three ♀♀, 22.0 + 5.0 to 28.5 + 7.25 mm.

Western English Channel: 6 mi W. Rame Head (Cornwall), one, t.l. 11.0 mm., midw. in 48 m., 24 Oct. 1913 (Clark, 1914). Rame Penlee, one, 6.5 mm., 13 m., 3 July 1919; $5\frac{1}{2}$ mi WSW. Rame, one, 5.0 mm., 38 m., 21 July 1919; $4\frac{3}{4}$ mi S. by W. Rame, two, 4.0 and 7.0 mm., 31 July 1919; $3\frac{1}{4}$ mi NE. by E. Eddystone, one, 6.0 mm., midw. in 55 mm., 5 Aug. 1919; $3\frac{3}{4}$ mi S. 14 W. Rame, two, 5.0 and 6.0 mm., 41 m., 5 Aug. 1919; 4 mi S. 17 W. Rame, one, 7.0 mm., midw. in 41 m., 8 Aug. 1919; $\frac{1}{2}$ mi E. Eddystone, two, 6.0 and 7.0 mm., 37 m., 8 Aug. 1919; 5 mi SW. by W. Rame, one, 5.0 mm., 50 m., 11 Aug. 1919; 20 mi S.W. 5 W. Eddystone, eleven, 5.0 to 12.0 mm., surf. and midw. in 75 m., 9 Sept. 1919 (Clark, 1920). Off Plymouth Sound (50° 17' to 18' 30" N., 4° 10' to 11' W.), three at 3.8-18.1 m., 13/27 June 1924; 10 mi SW. Eddystone, eight, 17 June 1924, and two, 15 July 1926, at 12.4-57.8 m.; 5 mi N. Eddystone, eighteen, at surf. to 52 m., 25 June 1924/30 June 1926; c. $2\frac{1}{2}$ mi N. Eddystone, six, at 14-30 m., 17/19 June 1925; 2 to 3 mi E. Eddystone, one hundred and thirty, at 3.3-43.1 m., 1 July 1925/22 Sept. 1926; other postlarvae recorded May/Oct. and Dec. 1927; July/Oct. 1929; June/Oct. 1930/34; May, Sept. and Oct. 1935; June, July and Oct. 1938; Aug. 1939 (Russell, 1926a, b, 1930a, b, 1935, 1936, 1939, 1940). 200 to 300 yds. (4 to 6 cables) NNW. Eddystone, occasional, sh.gr. (Marine Biological Association, 1957; ground described by Smith, 1932). Falmouth Harbour (Cornwall), one ♀, t.l. 21.0 mm., 33 m., sh., 13 July 1897 (Holt & Byrne, 1898). 34 to 47 mi S. 17° to 27° W. Eddystone, one, t.l. 33.0 mm., 90-97 m.; 46.4 mi S. 25 W. Eddystone, one, t.l. 31.0 mm., 91 m., sh.st.gr.s. (Crawshay, 1912).

FRANCE

Western Channel: estuaries of Morlaix and Penzé, near Roscoff (Finisterre), fifteen, 10.0 + 3.0 to 17.5 + 4.5 mm., 5-8 m., "maerl" (Le Danois, 1910, 1913). Baie de Morlaix, Roscoff, "rare", 4-15 m., sh.maerl (Cantacuzene, 1956). Off NW. Finisterre (48° 40' N., 5° 4' W., and

48° 43' N., 4° 45' W.), one, t.l. 7.0 mm., in 113 m., s., 7 May 1906, and two, t.l. 11.0 and 12.0 mm., in over 100 m., st., 19 Sept. 1910, respectively (Fage, 1918 ; Schmidt, 1912).

Bay of Biscay : Sables d'Olonne (46° 27' N., 6° 30' W.), two, t.l. 24.0 mm., 166 m., m.s., 20 July 1886 (Collett, 1896).

DOUBTFUL RECORDS

Fage (1918) regarded larval fishes from the Straits of Gibraltar (Atlantic) as possibly referable to *Gobius scorpioides*, at the following stations : 35° 45' N., 5° 59' W., sh.st., in 58 m., 21 Feb. 1909 ; 35° 50' N., 6° 3' W., st., in 490 m., 21 Feb. 1909 ; 35° 57' N., 6° 0' W., m., in 275 m., 23 June 1910 ; 35° 51' N., 5° 58' W., clay, in 343-720 m., 8 Sept. 1910. Station details are from Schmidt (1912).

